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NOTES

BOOK REVIEW

NEW BOOKS

Redescription of Bibron's coral snake, *Calliophis bibroni* Jan 1858 with notes and new records from south of the Palghat and Shencottah Gaps of the Western Ghats, India

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(with four text-figures)

ABSTRACT.– Bibron's coral snake, *Calliophis bibroni* Jan 1858, is a rare and venomous snake known from the Nilgiri region of the Central Western Ghats, in northern Kerala, southern Karnataka and north-western Tamil Nadu. We present a summary of morphological characters from type material, other voucher specimens, and fresh collections made from the Western Ghats. We illustrate the colour of adults and a juvenile, and present an analysis of the colour pattern showing ontogenetic change. Using all known locality records, we provide a map of the distribution of the species that extends the range of the species considerably, from the Agumbe hills in the north to the Agastiyar hills in the south, across the Palghat and the Shencottah gaps. One of the specimens reported here represents the largest known individual to date (880 mm TL) and another, the smallest ever collected (185 mm TL).

KEYWORDS.– Elapidae, Elapinae, Calliophini, *Calliophis bibroni*, Bibron's coral snake, India, Western Ghats, Palghat Gap, Shencottah Gap.

INTRODUCTION

Coral snakes are typically small and venomous terrestrial snakes of the family Elapidae, which also includes the large cobras and kraits. These snakes now encompass the tribe Calliophini of the subfamily Elapinae (Castoe et al., 2007). The coral snakes are the least known group of venomous snakes in Asia and the Indian subcontinent. Five species of coral snakes are currently known to occur in India, four belonging to the genus *Calliophis* and one to the genus *Sinomicrurus* (Slowinski et al., 2001). All four species of *Calliophis* are found in peninsular India and three of these have their distributions mainly along the Western Ghats (Smith, 1943; Whitaker and Captain, 2004).

The Bibron's coral snake, *Calliophis bibroni*, was first described by Jan (1858) from the "Western Ghats". Subsequently, reports were made by Beddome (1864) from Manantoddy, Malabar (now Waynaad district, Kerala). Boulenger (1896) presented scale counts of four specimens collected by Beddome. Later, Wall (1919) reported on a young specimen of this species and regarded the species as rare. The locality reported for this specimen was Rockwood Estate, in the "Nilgiri Wynaad", at 3800–4000 ft. elev., a locality currently in the Nilgiri district of Tamil Nadu. Shankar and Ganesh (2009) report on two female specimens representing the northernmost localities known for the species, from the Agumbe region of Karnataka, and

include photos of a live specimen, ecological notes, and selected characters of external morphology in tabular form. Very little is known about the distribution, natural history and ecology of *Calliophis bibroni*, and the species is considered endangered according to the Conservation Assessment and Management Plan for reptiles in India (Molur and Walker, 1998). Herein, we report on recent records from south of the Palghat gap, in extreme south India, and provide notes on the natural history, taxonomy, colour ontogeny and morphological variation of the species.

Materials and Methods

Museum specimens of coral snakes were examined from the collection of the Bombay Natural History Society (BNHS), the British Museum of Natural History (BMNH), the Madras Museum (MAD), the California Academy of Sciences (CAS), the Muséum National d'Histoire Naturelle (MNHN), the Zoological Survey of India main collection (ZSI-Calcutta), and the Zoological Survey of India Western Ghats Regional Station (ZSI-Calicut), see Table 1. In addition, some morphological characteristics were obtained from written accounts and/or illustrations presented by Beddome (1864, 1867), Boulenger (1890, 1896), Jan (1858), Shankar and Ganesh (2009), Sharma (1998), Slowinski

Table 1. The collection and locality details of specimens of *Calliophis bibroni*.

Map No.	Locality	Voucher	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (meters)
1	Karnataka: Chikmagalur: Mandal Mane	Shankar & Ganesh (2009)	13.4000	75.2300	664
2	Karnataka: Coorg: [Madikeri]	BMNH 1937.4.3.15	12.4167	75.7333	1061
		BNHS 2119			
3	Karnataka: Shimoga: Thirthahalli	Shankar & Ganesh (2009)	13.7000	75.2300	667
4	Kerala: Calicut: Cherupuzha	ZSI-Calicut 12-vi-1996	12.2726	75.3622	50
5	Kerala: Calicut: Thottada	ZSI-Calicut 18-viii-1996	11.8423	75.4214	47
6	Kerala: Kannur [Cannanore, at Kannur]	Sharma (1998; Pl. 7)	11.8693	75.3672	1
7	Kerala: Kottayam: Pala: Kalamukulam	Sunilkumar (2001)	9.7694	76.7683	120
8	Kerala: Trivandrum: Chathankode	BNHS 3460	8.65	77.15	180
	Kerala: Wynaad [Wayanad]	MAD (no number)	Unknown	Unknown	Unknown
9	Kerala: [Wayanad]: Mananttody, Malabar	BMNH 1946.1.17.93 (Holotype of *C. cerasinus*)	11.8013	76.0051	759
10	Kerala: Wynaad [Wayanad]: [Sultan Battery]	BMNH 72.1.2.7	11.6667	76.2833	906
		CAS 17268			
11	Tamil Nadu: Pollachi: Anamalai Tiger Reserve: Karuneerppallam	ZSI-Calicut 2123	10.3732	76.8746	450
11	Tamil Nadu: Pollachi: Anamalai Tiger Reserve: Topslip: Road near Erumapara	ZSI Kolkata 25638	10.4642	76.8368	700
12	Tamil Nadu: Pollachi: Anamalai Tiger Reserve: Topslip: Karian Shola main trail	ZSI Kolkata 25639	10.2815	76.5011	700
13	Tamil Nadu: Nilgiris: Mudumallays [at Madumalai Nat. Park]	BMNH 74.4.29.51 BMNH 74.4.29.53	11.5764	76.5832	980
14	Tamil Nadu: Nilgiris: Rockwood Estate	BMNH 1922.5.25.58 [Wall, 1919]	11.5262	76.4007	1220
	South India	ZSI Kolkata 11376	Unknown	Unknown	Unknown
	Western Ghats	MNHN 5070 (holotype of *C. bibroni*)	Unknown	Unknown	Unknown

et al. (2001), Smith (1943), Sunilkumar (2001) and Wall (1919).

Most measurements of external morphology were taken from digital images using the software ImageJ (Rasband, 2004). Photographs were taken with high resolution digital cameras (> 8 mega pixels), placing the subject at right angles with respect to the lens of the camera. Snout-vent length (SVL), tail length, and total length (TL) were taken to the nearest mm using the imaging software or a measuring ruler or tape. On a few occasions, morphological measurements were taken using Mitutoyo™ dial vernier calipers (0.05 mm accuracy).

Terminology for scales follows standard colubroid terminology (e.g., Smith and Campbell, 1994). The method of counting ventrals is that of Dowling (1951). The terminal scute (tip) is excluded from the number of subcaudals. Dorsal scales were counted at two head lengths from the head, mid body (corresponding to half the number of ventrals) and two head lengths before the vent, respectively. Values for asymmetric head characters are given in left/right

order. For specimen ZSI-Calicut 2123 scale counts and other characteristics were recorded at the time of discovery.

Colour descriptions and images presented of living or freshly killed specimens are based on electronic images. One of these images (from S. D. Biju, Fig. 1A) was digitized from a colour transparency and age/brand colour corrected. These images are deposited at the Image Collection of the UTA Amphibian and Reptile Diversity Research Center.

Results

Taxonomic notes.– Through recording data from specimens of *Calliophis bibroni* at various museums and comparing them to early descriptive accounts by the authors cited above, we have been able to associate particular specimens to these accounts or notice designation discrepancies. Captain R. H. Beddome described *C. cerasinus* in 1864 and designated no specimen in particular as the holotype. In 1867, Beddome presented the description a second time and provided a colour lithograph. The species

Figure 1. *Calliophis bibroni.* **(A)** Adult male, 681 mm SVL, from Chathankode, Trivandrum district, Kerala (BNHS 3460). Reproduced from UTADC 2822, photo by S. D. Biju. **(B, C)** Dorsal and ventral views of largest known specimen, adult male, 782 mm SVL, from Karuneerppallam, Anamalai Tiger Reserve, Tamil Nadu (ZSI-Calicut 2123). Showing extremely dark inter-band dorsal color and dark ventral pigmentation over red background. Reproduced from UTADC 2606, photo by V. Deepak. **(D)** Juvenile female, 168 mm SVL, from Erumapara, Topslip, Anamalai Tiger Reserve, Tamil Nadu (ZSI- Calcutta 25638). Reproduced from UTADC 2607, photo by V. Deepak.

was short lived and by 1890, it was already re-
garded a junior synonym of *C. bibroni* (Boul-
enger, 1890). The holotype of *C. cerasinus* was
later presented by Captain R. H. Beddome to the
British Museum of Natural History (BMNH),
along with three additional specimens. The se-
ries was assigned the numbers BMNH 72.1.2.7,
specimen accessioned on 2 January 1872, and
BMNH 74.4.29.51–53, specimens 51–53 ac-
cessioned on 29 April 1874. In the Catalogue of
the Snakes in the British Museum, Boulenger
(1896) provides ventral and subcaudal counts
for four specimens (those presented by Bed-
dome) but unfortunately did not give number
designations. The first specimen, a female with
224 ventrals and 34 subcaudals, from "Wynad,
3000 ft." is indicated as the "type for *C. cerasi-
nus*". These counts correspond to the first speci-
men of the series, BMNH 72.1.2.7. Specimen
BMNH 74.4.29.52, probably a male, has been
considered the holotype of *C. cerasinus* since
the holotype evacuation during World War II,
and was re-registered after the war as BMNH
1946.1.17.93. We have noticed that the original
description by Beddome (1864) does not match
the presently designated holotype, BMNH
1946.1.17.93 (original number 74.4.29.52) or
that indicated by Boulenger (1896). Careful ex-
amination and comparison of morphology (total
length, number of bands, ventrals, subcaudals,
sex, and dorsal colour) of all *C. bibroni* depos-
ited at the BMNH and ZSI reveals without any
doubt that the specimen described by Beddome
(1864), the holotype of *C. cerasinus*, is BMNH
74.4.29.51, a female with a dark dorsum, 227
ventrals, 32 subcaudals, 41 dorsal bands, 529
mm total length, and 49 mm tail length. Our
band and scale counts for BMNH 74.4.29.51
differ from those of Beddome (1864, 1867) by
no more than one, and the ventral counts
for the other BMNH specimens differ by five
or more (but the methods of counting ventral
scales were different). Our measurements are
also very close, for example, the tail length of
BMNH 74.4.29.51 differs in less than 2 mm
from that given by Beddome (1864, 1867). Bed-
dome (1867, Fig. 5) also presented a lithograph
depicting a dorsal and a ventral section of the
body of a specimen and a lateral and dorsal line
drawing of the head. We have not been able to
associate the illustrations to those of any par-

ticular specimen we have examined, and it most
likely represents a different specimen.

Wall (1919) presented a detailed description
of a juvenile *Calliophis bibroni* from Rock-
wood Estate, unfortunately without any muse-
um designation. We have been able to associ-
ate this specimen, based on Wall's description,
to a specimen donated by him to the BMNH,
number 1922.5.25.58. Wall's (1919) description
of the specimen matches our counts and meas-
urements (in parentheses), having 8 3/8 inches
in length (about 213 mm compared to 197 mm),
219 ventrals (220), 35 subcaudals (35), flesh col-
our with 33 complete black bands on the body
(33) and 6 on the tail (6). He also described the
snake as having a broad, white, parieto-occipital
band on the head, divided mesially by a black
line (concordant with BMNH 1922.5.25.58).

Another discrepancy we have found has to
do with our modern interpretation of the over-
all size reported by Jan (1858) for the holotype
of *C. bibroni*, MNHN 5070. The specimen was
reported as measuring 47" in total length and
having a tail 6" long, measurements indicated
by a double prime in the original publication.
Currently the double prime denotes inches and
the measurements would correspond to total
and tail lengths of 1175 and 152 mm, respec-
tively, a very large specimen. At this time in
France, the double prime often also denoted a
pouce or inch, the value of which was variable
across Europe (Anonymous, 2009a). During the
beginning and middle of the nineteenth century,
France and Italy, respectively, were undergo-
ing metrication, adopting the metric system
(Anonymous, 2009b). Jan in 1858 was based at
the museum in Milan and the article of our con-
cern was in French and from a Parisian outlet.
During this time many of the old symbols (e.g.,
the double prime) were used for the new metric
system (Anonymous, 2009c). Our new meas-
urements of the holotype of *C. bibroni*, MNHN
5070, kindly provided by I. Ineich (MNHM),
confirm that these were in centimeters. Jan's
(1858) measurements match ours (in parenthe-
ses) closely, 47" in total length (48.9 cm) and
having a tail 6" long (5.5 cm).

Colouration and ontogeny.– Detailed colour
accounts for specimens of *Calliophis bibroni*
have been presented for single specimens by
Beddome (1864, 1867, descriptions of holotype

C. cerasinus and another specimen as lithograph) and Wall (1919, juvenile), and for two unvouchered but well documented females by Shankar and Ganesh (2009). Further examination of specimens of *Calliophis bibroni* reveals a remarkable variation in dorsal colour and pattern. Since we report on specimens coming from across important biogeographic barriers to the distribution of many species in the Western Ghats we considered it important to analyze in detail the variation present in *C. bibroni*. According to Smith (1943), the dorsal colour of this species varies from "cherry-red to dark purplishbrown", and the juvenile recorded by Wall (1919) was flesh coloured with 33 black bands on the body and six on the tail. The adult female described by Beddome (1864) had a "purplish brown" back, now light brown. This dark dorsal colour occupies the median 11 dorsal scales. The dorsum of the holotype of *C. bibroni*, an adult individual, was described by Jan (1858) as pale brown with black crossbars and the colour perhaps altered by alcohol; now the specimen is extremely pale with relatively light-brown crossbars. In the mature male and largest known specimen (880 mm TL), ZSI-Calicut 2123, the median 9 dorsal scale rows were dark purplishbrown, while the two outermost scale rows on either side were red. The black cross bands were wider dorsally. Laterally, the red coloured interspaces were broader and the black bands were narrow (Fig. 1B). The belly was pinkish-red with large black-squarish spots (Fig. 1C). Both Smith (1943) and Wall (1919) mentioned their specimens having a white band on the head (parieto-occipital band) separated by a black line mesially. In our specimen, the head was black except for the last 2.5 supralabials, postemporal and postsupralabials, also red, and this colour description matches well with the one made by Beddome (1864). Just a decade ago Sharma (1998) published a photograph (Pl. 7) of a young coral snake from Kanur, Kerala mistakenly identified as *Calliophis [Sinomicrurus] macclellandi*. The plate illustrates a specimen

that coincides with the descriptions of *Calliophis bibroni* of Smith (1943) and Wall (1919). This specimen has a continuous red colour on the dorsal areas between dark bands but lacks the white parieto-occipital band, this band is red, even laterally, coinciding with other specimens reported herein. Regarding colour pattern, we found an abrupt and remarkable ontogenetic change (Fig. 2). Juveniles tend to have a bright red dorsal colour with high contrast to black/dark brown dorsal bands; with maturity the red upper dorsal scales tend to darken, resulting in a nearly uniform dark dorsum from head to tip of tail. Figure 2 also shows that this change takes place between 350 and 450 mm in SVL, and that females might darken at smaller sizes. If age and size, and maturity and ontogenetic colour change are correlated the figure suggests that females mature and darken earlier than males and males attain a larger size and perhaps live longer. The two females reported by Shankar and Ganesh (2009) agree with the pattern observed, one of them is the largest known female—556 mm in SVL and is described as having a dark purplish back. The other specimen reported by Shankar and Ganesh (2009), with 416 mm in SVL and 36 body bands, lies within the range of ontogenetic colour shift found by us. This last specimen shows dorsal dark colouration anteriorly and a juvenile pattern posteriorly, an observation that suggests ontogenetic colour change starting from the neck towards the tail.

Morphological variation.– Until recently very few specimens of *Calliophis bibroni* have been reported. We take the opportunity to present the variation of some coral snake characteristics in tabular form (Table 2) and some additional detailed descriptive morphology for one of the recently collected specimens, the largest speci-
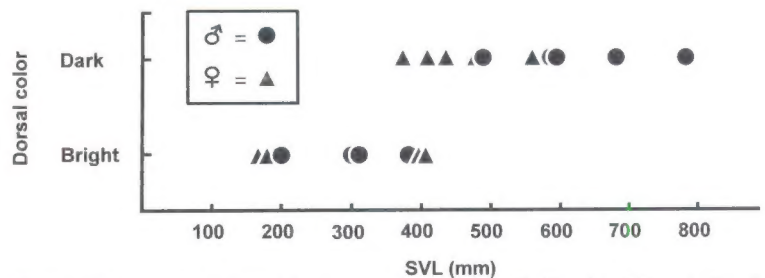
Figure 2. Ontogeny of dorsal background colour in *Calliophis bibroni*. Graph shows darkening of dorsum in males and females happening at near 400 mm in SVL. Notice larger sizes in males.

men of *C. bibroni* collected, ZSI-Calicut 2123. Photographs of the body (Fig. 1B & C) and head (Fig. 3) of this snake are presented to show diagnostic characters. The snake being a male, a hemipenis was everted by pressing the base of the tail with the thumb.

The maxilla has one small tooth behind the fang. The diameter of the eye (1.45 mm) is about half its distance from the mouth (2.70 mm), not twice its distance from the upper lip as given by Smith (1943). The preoculars are absent and the prefrontals are in contact with the orbit and third supralabial, on both sides of the head. A single postocular scale is present on each side. One long, anterior temporal scale is present on either side of the head, followed by a small second temporal. The upper lip has seven supralabials on each side, the third and the fourth enter the orbit and the fifth, sixth and seventh contact the anterior temporal scale. There are six infralabials on each side of the head, with the first pair elongated and in contact medially, forming a long suture. The fourth infralabials are the largest. The genials of the anterior pair are smaller than those of the posterior pair, and the latter contact the third and fourth infralabials. The dorsal scales are smooth and in 13 rows throughout the body. There are 3 preventrals and 229 ventrals, two scales more than the maximum in the range presented by Smith (1943) (219[220]–227). The anal scale is undivided and the tail has 36 subcaudal scales. The hemipenis is spinose throughout and extends to the seventh caudal plate. This specimen is the largest individual of Bibron's coral snake reported so far (snout-vent length 782 mm, total length 880 mm).

New distributional records and natural history notes.– There are currently no vouchered reports for *Calliophis bibroni* from south of the Palghat gap in the Western Ghats of India. Herein we report on five specimens of *Calliophis bibroni* collected south of the Palghat Gap in the Anamalai hills and one of them south of the Shencottah Gap in the Agastiyar Hills, well into the southern tip of the Indian Peninsula. The first and southernmost specimen is a large male (BNHS 3460, Fig. 1A) collected by S. D. Biju at Chathankode, Trivandrum district, Kerala on 13 July 2002. The snake was discovered while S. D. Biju was digging for caecilians in a fringe of wet
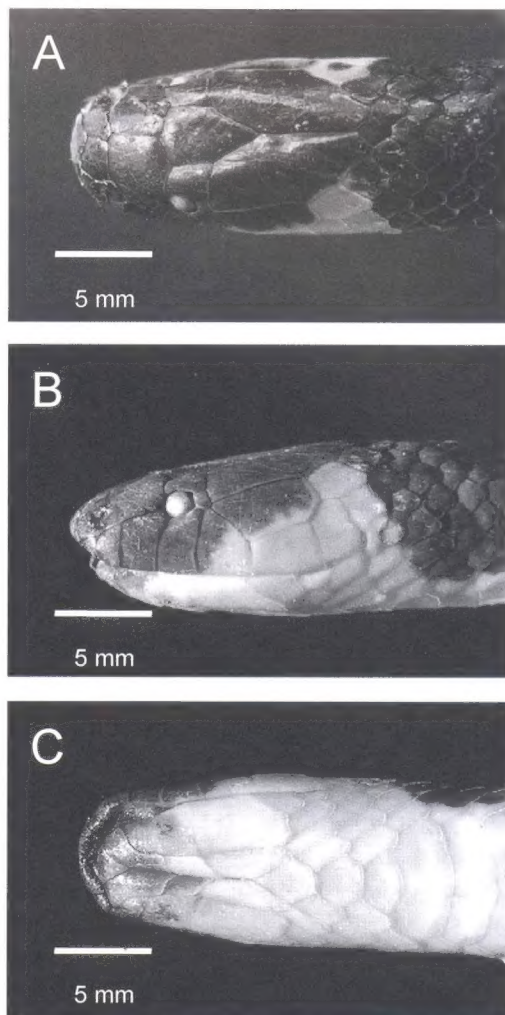
Figure 3. Dorsal (**A**), lateral (**B**) and ventral (**C**) views of the head of *Calliophis bibroni*, specimen from Fig. 1B&C. Photo by V. Deepak.

secondary forest near a perennial stream. The second specimen (ZSI Calicut 2123, Fig. 1B & C), is the largest known male and was collected by V. Deepak at a riparian habitat in Karuneerppallam, Manamboli range of the Anamalai Tiger Reserve, Tamil Nadu, at 1130 h on 12 January 2007. This individual was discovered dead and had punctures on its ventral scales, probably inflicted by an avian predator. The third specimen is a juvenile female (ZSI Kolkata 25638, Fig. 1D) found on a road crossing evergreen forest, near Erumapara, at Topslip, Anamalai Tiger Reserve. The snake was collected by V. Deepak on 5 August 2008. The fourth specimen (ZSI Kolkata 25639), a large male, was
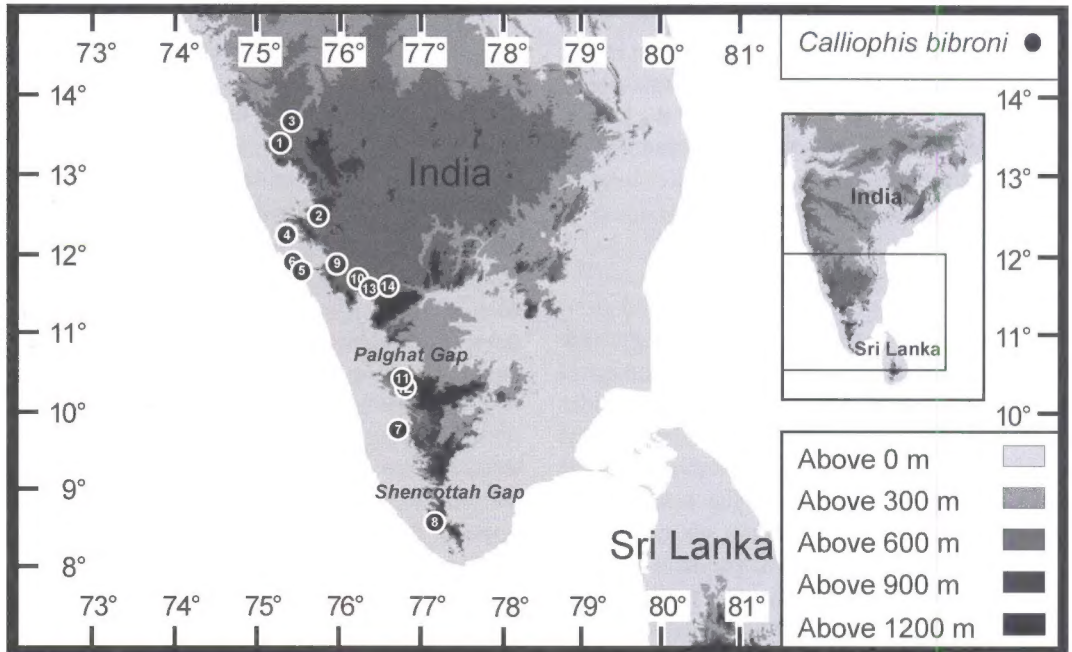
Figure 4. Map of southern India showing collection localities for *Calliophis bibroni*. Numbers correspond to those of Table 1.

collected at the main trail of Karian Shola, also at Topslip, Anamalai Tiger Reserve. The snake was found by V. Deepak at 0930 h on 27 January 2009. The collection site is located within wet-evergreen forest. The fifth specimen originated from Kerala, in the town of Kalamukulam. It was collected by P. K. Unnikrishnan and

was first reported with a full body photograph (UTA digital collection UTADC 2605) on the Kerala newspaper *Mathrubhumi Daily* (Sunilkumar, 2001). The snake was reported as having a white patch behind the head, a purplish body with black crossbars, a "coral red" belly, and being approximately 1.5 ft in total length (ca. 457

Table 2. Selected characters in male and female *Calliophis bibroni*. Two specimens were not examined directly and therefore could not be sexed. For these specimens, data was obtained from photos and associated figure captions in Sharma (1998, Pl. 7) and Sunilkumar (2001). Supralabial and infralabial counts are given as left/right. Subcaudal scales are counted in pairs but the number of subcaudals with blotches is not (counted individually). Data provided for two females by Shankar and Ganesh (2009, Table 1) were incorporated as possible. When their character definitions probably differed from ours, we provide their data in bold (e.g., preventrals are not distinguished from ventrals). Blotch counts are also not provided by them.

Selected character	Males ♂ n = 9	Females ♀ n = 9	Unknown sex n = 2
SVL	199–782	168–556	NA
Total Length (TL)	220–880	185–601	250–457
Tail/TL	0.09–0.13	0.09–0.12, **0.07, 0.08**	NA
Supralabials	7/7 (7/8)	7/7, **6/6**	NA
Infralabials	6/6 (5/5, 6/7, 7/7)	7/7 (5/5, 6/6, 6/7)	NA
Preventrals	3	3	NA
Ventrals	221–229	220–227, **229, 234**	NA
Subcaudals	31–37	26–36	NA
Dark body bands	32–40	33–39	33-35
Dark tail bands	3–9	3–9	7
Ventrals with blotches	40–126	59–138	NA
Subcaudals with blotches	4–43	1–45	NA

mm). The snake was kept in captivity by P. K. Unnikrishnan and was fed one small rat snake (probably *Ptyas mucosa*) and two blindsnakes (Typhlopidae) over a week. A map of the known records of *Calliophis bibroni* is presented as Fig. 4 and the geo-referenced localities used to create the map as Table 1.

Discussion

Calliophis bibroni is easily distinguished from other species of coral snake occurring south of the Palghat Gap (namely, the striped coral snake, *Calliophis nigrescens*, and the slender coral snake, *Calliophis melanurus*) by external characters such as: the absence of a preocular scale, having a single postocular scale, and a colour pattern of dark cross-bars along the body (longitudinal stripes or no stripes in *C. nigrescens*, and only dark cross-bars in the head and the tail regions in *C. melanurus*). The other species known from peninsular India, Beddome's coral snake- *Calliophis beddomei*, is known from only five specimens and from three localities, and has not been reported from the Western Ghats south of the Palghat gap (Smith, 1943; Smith et al., 2008). The key morphological characters which distinguish this species from all other coral snakes recorded from India (namely, *C. beddomei, C. nigrescens, C. melanurus,* and *Sinomicrurus macclellandi*) are: the absence of a preocular scale, a single postocular scale, prefrontals in contact with the eye, a single anal shield and the presence of only one minute tooth behind the poison fang.

The records from eighteen specimens (Table 1 and Fig. 4) show that *Calliophis bibroni* is distributed along a wide altitudinal range in the Western Ghats (0–1220 m). The records presented in this study extend the known range of this species by approximately 230 km to the south and importantly, south of the Palghat and Shencottah Gaps of the Western Ghats.

The remarkable ontogenetic change in *Calliophis bibroni* seems to be unique among coral snakes. Most coral snakes possess bright colours —red, yellow, orange or blue— and are thought to be aposematic in function (Campbell and Lamar, 2004; Brodie and Brodie, 2004), while colour patterns that match the environment—e.g., brown or green blotching or solid earth colours- are thought to be cryptic, cam-

ouflage. Sometimes these colour patterns get stripes or bars – disruptive colouration particularly useful during escape. Coral snakes in India have different types of colours. *Calliophis beddomei, C. melanurus* and *C. nigrescens* have dorsal cryptic colours, with a disruptive pattern of lines and/or blotches (*C. melanurus* and *C. nigrescens*), or sometimes unicolored (*C. nigrescens* [Wall, 1928]). The undersides of *Calliophis melanurus* and *C. nigrescens* possess aposematic colours. *Calliophis beddomei* is peculiar among coral snakes for being "whitish below" (Smith 1943) and thus having no aposematic colours. *Sinomicrurus macclellandi* has a red dorsal colour usually with black bands (one white on the head) although in some populations there might be only a faint vertebral stripe or a stripe and a few lateral blotches, or it might be unicolor red-brown, the venter is usually pale yellow with some black spots to having well defined crossbars (Whitaker and Captain, 2004). *Sinomicrurus macclellandi* seems to be aposematic above and sometimes disruptive above or below. *Calliophis bibroni* has a very unique condition, in which small individuals tend to be aposematic and disruptive overall and then shift to being cryptic above and remaining aposematic and disruptive below. Most coral snakes, particularly in the New World, tend to be brightly coloured at birth and then gradually become slightly darker or dusky (ENS personal observation), but always remain with the same basic colour pattern. We are unaware of any other coral snake with an extreme ontogenetic color change as that seen in *C. bibroni*, a shift from aposematic and disruptive bars to unicolor dark.

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Ontogeny of the vertebral column in
Polypedates maculatus (Anura: Rhacophoridae)

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(with four text-figures)

ABSTRACT.– We discuss proximo-distal sequential pattern of development of the vertebral column in *Polypedates maculatus* (Anura: Rhacophoridae). Development of the centrum presents a transitional state between a true perichordal and a true epichordal mode in all vertebrae except atlas in which the centrum development is in a perichordal mode. The neural arch of each vertebra develops as two basidorsals or dorsal arcualia, which finally meet mid-dorsally. The diapophyses of sacral vertebrae ossify earlier than the last four presacrals, thus providing firm attachment with the ilium during metamorphosis.

KEY WORDS.– Ontogeny, vertebral column, ossification, chondrification, *Polypedates maculatus.*

Introduction

The vertebral column starts its formation from the notochord. The sclerotomic cells, after differentiating from the lateral mesoderm of the notochord, form a continuous´ skeletogenous perichordal tube around the notochord (Gegenbaur, 1862; Gadow, 1896). It is the perichordal tube which takes part in the formation of the centrum. In chordacentric individuals, the perichordal tube is partly used, while in archocentric individuals, it is solely used in formation of the centrum. The neural arches or the dorsal arcualia are not involved (Mookerjee, 1931, 1936). In anurans, development of the centrum is either of epichordal or perichordal mode. However, the atlas has a perichordal mode of development in anurans (Mookerjee, 1931, 1936). The inter-vertebral region is also formed from the perichordal tube (Mookerjee, 1931, 1936). The perichordal tube consists of migratory connective tissue which determine the type of vertebrae (i.e. whether procoelous, opisthocoelous, amphicoelous or acoelous, (Dey et al., 1989).

There are several reports on the osteological development of the vertebral column in anurans.

Gegenbaur (1862) and Gadow (1896) described the vertebral column development in *Rana, Bufo, Pseudis* and *Bombina* (*Bombinator*); Ridewood (1897) in *Pipa* and *Xenopus*; Mookerjee (1931) in anurans in general; Mookerjee and Das (1939) in *Rana afghana, Microhyla rubra* and *Polypedates maculatus;* Ramaswami (1939) in several rhacophorids and ranids; Lynch (1973) in adult microhylids; Clarke (1987) in *Barbourula*; Dey et al. (1989) in *Microhyla ornata*; Wiens (1989) in *Spea bombifrons*; Pugener and Maglia (1997) in *Discoglossus sardus*; Haas (1999) in *Pyxicephalus adspersus*; Trueb et al. (2000) in *Pipa pipa*; Banbury and Maglia (2006) in *Spea multiplicata* and Handrigan et al. (2007) in nine megophryid anurans.

The ontogeny of vertebral column development of *Polypedates maculatus* described earlier by Mookerjee and Das (1939) was based on only histological preparation and there is no description on development of vertebral column as a whole in this species. The present paper describes development of vertebral column through differential bone and cartilage staining without sectioning the vertebral column.

Materials and Methods

Egg masses of *Polypedates maculatus* were wild-collected during the monsoon period. Tadpoles were reared following standard laboratory method (Mohanty-Hejmadi, 1977). Tadpoles of Stage 19–46 (Gosner, 1960) were fixed in 10% formalin at periodic intervals. The formalin fixed tadpoles were differentially stained with alcian blue (for cartilage) and alizarin red (for bone) following Wassersug (1976). Some stained specimens were dissected under binocular microscope to study individual vertebrae. All voucher material has been deposited with the Cell and Developmental Biology Laboratory, Department of Zoology, Utkal University, Bhubaneswar, Orissa, India. The developing vertebral column of specific stages was selected for photography, using a Leica™ stereomicroscope and a Pentax™ K1000 camera.

Results

The initiation and completion of chondrification and ossification of each vertebra and its associated processes at various stages of development has been indicated in Table 1.

Stages 19-25.– The beginning of cellular aggregation for the development of the vertebral column started at stage 19. The skeletogenous tissue cells aggregated along and around the entire notochord forming the perichordal tube. Laterally, this tube looked transparent.

Stages 26-28.– The whole perichordal tube was chondrified and became separated transversely by intervening cartilages. The perichordal tube was differentiated into vertebral and inter-vertebral portions; the dorso-lateral parts of the vertebral portions became cartilaginous while the inter-vertebral portions became membranous. (Fig. 1A). The cartilaginous segmentation provided identity to the future vertebrae of the vertebral column.

Stages 29-30.– By this stage, the neural arches of all the vertebrae had chondrified. The neural arches were also superimposed on the dorsal side of the perichordal tube. Development of the neural arches started from the dorsolateral corners of the perichordal tube, which proceeded dorso-medially above it. From the mid-dorsal portion of the neural arches of the vertebra II and III, cartilaginous diapophyses (transverse process) developed projecting antero-laterally. In other vertebrae (IV to VI), only cellular thickenings were observed (Fig. 1B).

Stages 31-32.– Ossification of the neural arches of vertebrae I to VI was observed in this stage (Fig. 1C).

Stage 33.– The neural arches of the vertebrae VII–VIII had started to ossify (Fig. 1D). In all the vertebrae, the neural arches of either side met at the mid-dorsal line, thus completing the neural arch. Ossification of the diapophyses of the vertebrae II and III was observed. Also, there was incomplete ossification of the neural arches and centra of the vertebrae I to VIII. The diapophyses of the vertebra VIII were partially developed.

Stages 35-39.– Ossification of the neural arch of the vertebra IX (sacrum) had started at stage 36–37 (Fig. 2A). The diapophyses of the vertebra IV began to ossify. In the remaining vertebrae the diapophyses were in a fibrous condition. By stages 38–39, the pre and post-zygapophyses were observed from vertebrae VI to IX; the diapophy-

Table 1. Sequence of chondrification and ossification of vertebral column in *Polypedates maculatus*. * = Gosner (1960) stage.

Elements of vertebral column	Onset of chondrification	Onset of ossification	Completion of ossification
Centrum			
I-VI	28*-30	31-32	40-42
VII-VIII	28-30	33	43
IX	28-30	36-39	43
X	28-30	40-42	46
Neural arch			
I-VI	28-30	31-32	40-42
VII-VIII	28-30	33	40-42
IX	28-30	36-37	44
X	28-30	36-39	46
Diapophyses			
II-III	28-30	33	38-39
IV	31-32	36-37	40-42
V-VIII	40-42	44	46
IX	40-42	40-42	46
Pre and Post Zygapophyses			
I-V	33	33	40-42
VI-IX	36-39	36-37	43
X	43	44	46
Neural spine	38-39	40-42	44

ses of the vertebra II and III were completely ossified (Fig. 2B).

Stages 40-42.– Ossification of the neural arches of the vertebrae occurred in an antero-posterior direction. The whole neural arches of the vertebrae I–VII had completely ossified. At this stage, ossification of the diapophyses of the vertebra IV was also completed. The diapophyses of the vertebra IX (sacrum) started to ossify along with the ossification of the vertebra X (Fig. 2C, D).

Stage 43.– Ossification of diapophyses of the vertebrae V–VIII was completed along with the perichordal rings of the vertebrae VII–IX (Fig. 3A, B).

Stage 46.– All the vertebrae were completely ossified (Fig. 3C, D) except for the atlas and urostyle (Fig. 4A–J). The vertebral centra were arch-like structures because of the erosion of the ventral portion of perichordal ring (Fig. 4B–I). The centrum of the atlas was a complete ring and presented a posterior convexity. It had two facets (atlantal condyle) at the anterior margin of the articulation with the occipital condyles. The centra of the pre-sacral vertebrae, from the vertebrae II to the VII, were procoelous. The centrum of the vertebra VIII was amphicoelous. The centrum of the vertebra IX was biconvex, with a single convexity anteriorly and double convexities posteriorly (these double convexities are the sacral condyles). At the anterior end of the urostyle, two concavities (cotyles) were present to receive the two posterior convexities of the sacral vertebra.

The neural spine of the atlas was reduced and inconspicuous. In the vertebrae II to VIII, the neural spine was short. The diapophyses of the vertebrae II to IV were small, flat and distally broad. The diapophyses of the II and III vertebrae were directed forward and those of the vertebra IV were directed backward. The diapophyses of the vertebrae V–VII were laterally directed and their ends were accuminate. The diapophyses of the IX vertebra or sacrum were cylindrical, stout and backwardly directed; they had iliac facets at the tip for the articulation with the ilium (Fig. 4A–J).

Discussion

The above results supports the previous report of Mookerjee and Das (1939) that the devel-

opment of vertebral centrum in *Polypedates maculatus* presents a transitional state between a true perichordal and a true epichordal mode. The centrum develops as perichordal, but subsequently with the degeneration of the ventral portion of the perichordal ring, the centrum becomes an arc, resembling the epichordal mode of development. According to Mookerjee and Das (1939), the development of the centrum of the atlas in *P. maculatus* follows epichordal pattern of development. The present study shows that in the atlas, the development of centrum is a true perichordal mode (i.e., the entire perichordal ring is chondrified and ossified, and there is no such degeneration of the perichordal ring). This further generalizes the statement that the atlas, irrespective of the anuran species, has a perichordal mode of development. Furthermore, it was reported that in *P. maculatus* the degeneration of the perichordal ring starts after chondrification of the ring (Mookerjee and Das, 1939). However, our observations indicate that the degeneration of the perichordal rings in all the vertebrae (II–IX) starts after its complete ossification.

Herein, we report the presence of a posterior convexity of the centrum of the atlas. Similar convexity has been observed in ranids (Mookerjee and Das, 1939; Ramaswami, 1939), microhylids (Trueb, 1973; Dey et al., 1989), bufonids (Gegenbaur, 1862; Gadow, 1896; Mookerjee, 1931) and rhacophorids (Mookerjee and Das, 1939; Ramaswami, 1939). The other seven vertebrae were procoelous. The eighth one was amphicoelous, the ninth was convex at both ends (one convexities anteriorly and two posteriorly) and the urostyle had two anterior concavities.

The pattern of development of the neural arches observed in the present study agrees with earlier reports (Mookerjee, 1931, 1936; Mookerjee and Das, 1939). The two basidorsals or dorsal arcualia developed from the dorsolateral corners of the perichordal tube, outside to it. These two basidorsals eventually met middorsally to complete the neural arch, and there was no supradorsal or a third piece element, as described in many urodeles (Mookerjee, 1936) and the anuran, *Rana afghana* (Mookerjee and Das, 1939: current name: *Amolops marmoratus*). Although the bases of the neural arches developed first, the middle portions of the arches
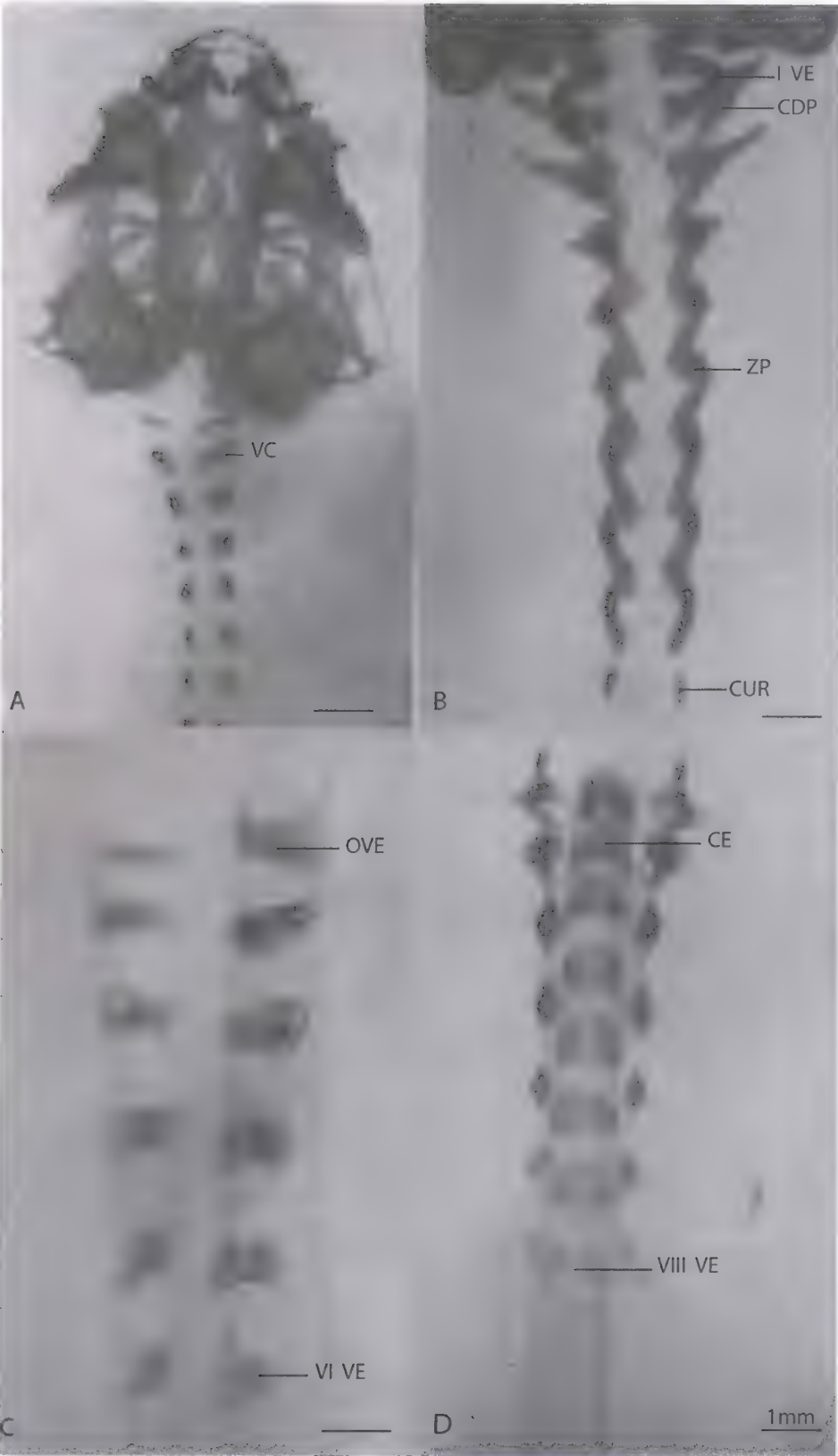
Figure 1. Vertebral column of *Polypedates maculatus* (Stage 26-33). A. (Stages 26-28) segmented cartilaginous vertebrae (Dorsal view). B. (Stage 30) Vertebral column showing chondrified neural arches, centra and diapophyses. Cartilaginous lateral vertebral process from II and III vertebrae (Ventral view). C. (Stages 31-32) Partial ossification up to VI vertebra (Dorsal view). D. (Stage 33) Vertebral column showing incomplete ossified centra and neural arches of I-VIII vertebrae (ventral view).
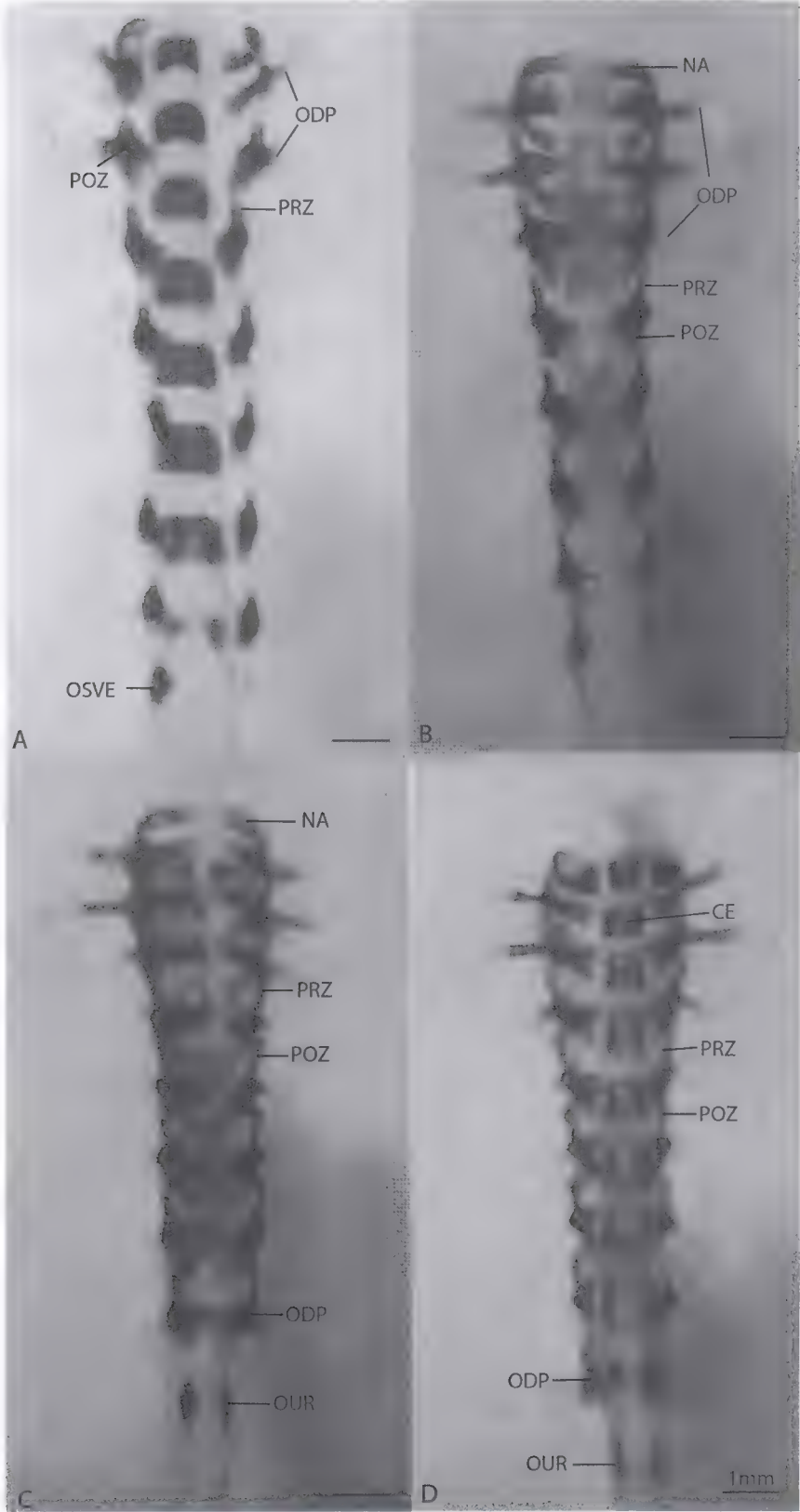
Figure 2. Vertebral Column of *Polypedates maculatus* (Stage 36-42)
A. (Stages 36-37) Incomplete ossification of IX vertebra and ossification of diapophyses of II and III vertebra (dorsal View). **B.** (Stages 38-39) Vertebral column shows ossified centra up to IX vertebra and ossification of diapophyses of II to IV vertebra. **C.** (Stages 40-42) (Dorsal view) Ossification of X vertebra along with ossification of diapophyses of V to IX vertebra (dorsal view). **D.** Ventral view of the same.
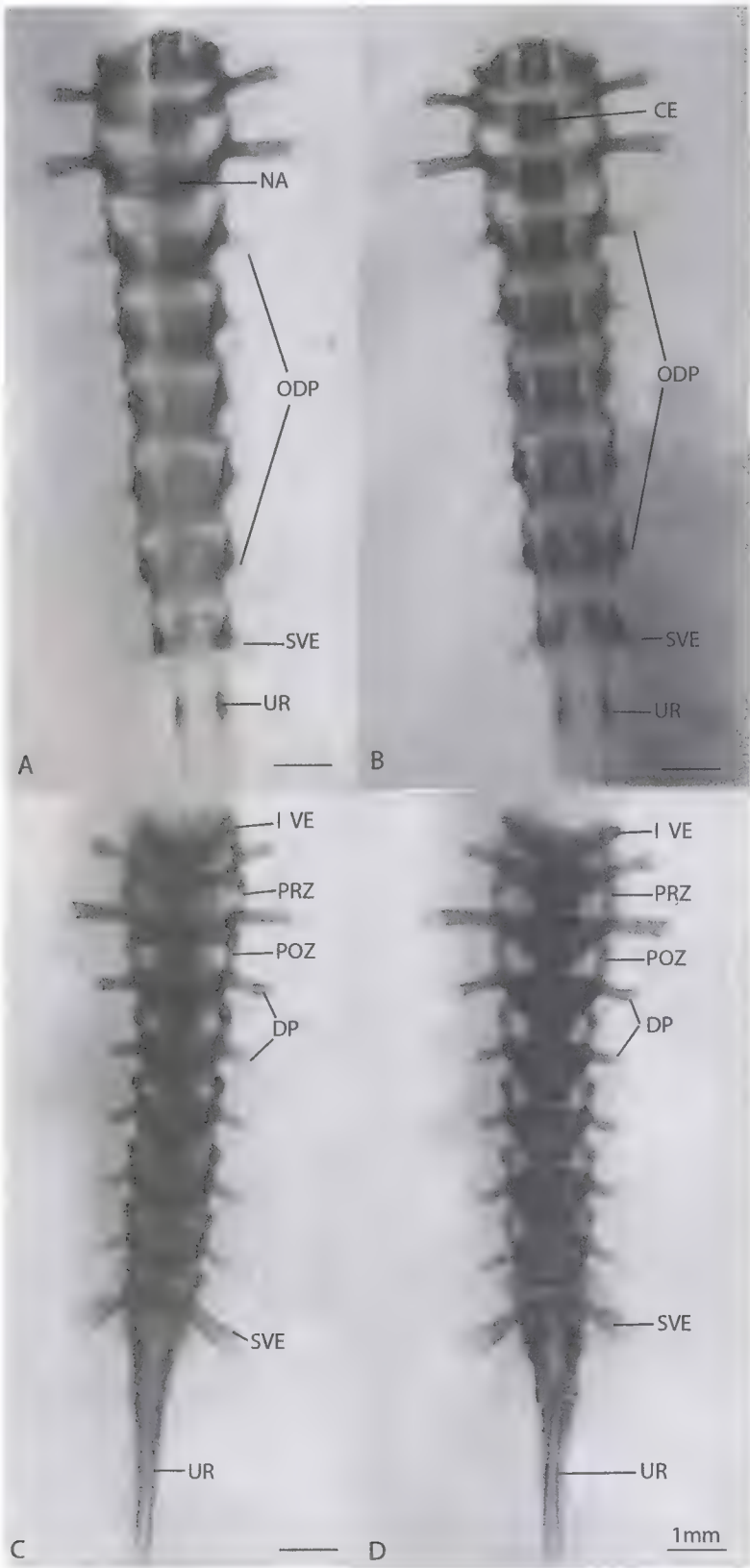
Figure 3. Vertebral Column of *Polypedates maculatus* (Stage 43–46)
A. (Stage 43) ossification of diapophyses of V to VIII vertebrae. (dorsal view) **B.** Ventral view of the same. **C.** (Stage 46) Complete ossification of all vertebrae; urostyle well developed with ossified neural arches and centrum (dorsal view). **D.** Ventral view of the same.
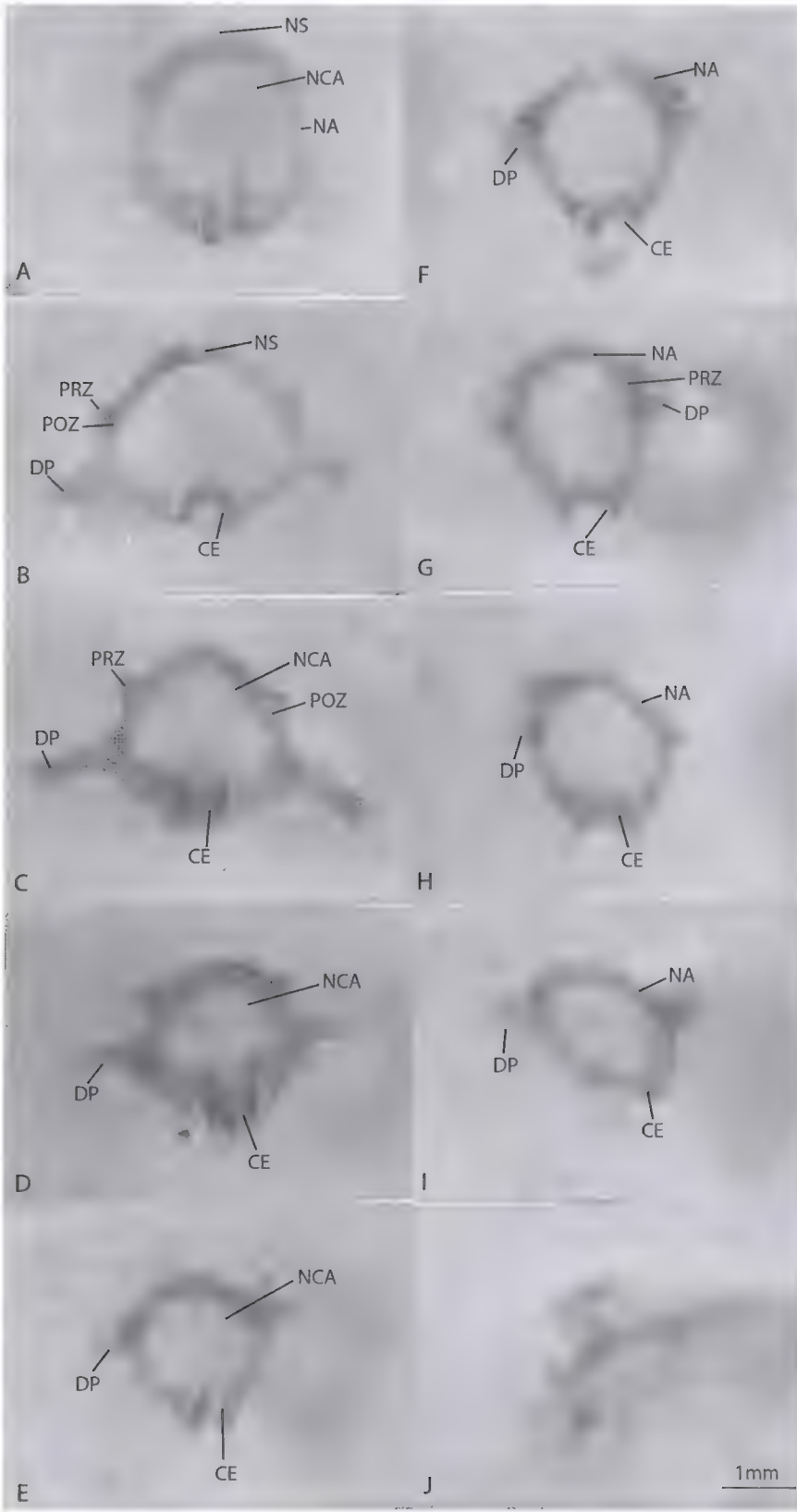
Figure 4. Disarticulated vertebrae of *Polypedates maculatus* (Stage 46) **A**. vertebra I showing complete ossification **B**. vertebra II showing procoelous centrum **C**. vertebra III **D**. vertebra IV **E**. vertebra V **F**. vertebra VI **G**. vertebra VII **H**. vertebra VIII **I**. vertebra IX **J**. vertebra X.

were ossified earlier than the bases. The neural arches did not take part in the formation of the centra. The neural spines developed from the mid-dorsal portion of the neural arches and were directed backwards.

Neural arches bear diapophyses (transverse process) laterally from second to ninth vertebrae. The diapophyses of the first three presacral vertebrae were stouter. The first transverse process was directed forward, the second parallel to vertebral axis while the third was directed backward. The diapophyses of V to VIII presacral were narrower than the rest and directed backward. The transverse process of sacrum was stouter and directed backward. In *Microhyla ornata*, the diapophyses of the sacrum were parallel to the vertebral axis (Dey et al., 1989). The present finding confirms earlier reports on variation in the arrangement of transverse process of vertebrae among anurans. The vertebrae from II to VIII had both pre- and post-zygapophyses, while the sacral had only pre-zygapophyses and the urostyle no zygapophyses.

The chondrification and ossification of the centra, neural arches, neural spines, diapophyses, pre and post-zygapophyses, followed a proximo-distal sequence. Similar vertebral column development in a cephalic-to-caudal sequence had been reported in a number of different anuran species (Maglia and Pugener, 1998; Sheil, 1999; Pugener, 2002; Magalia, 2003; Handrigan et al., 2007). The centra followed a dorso-ventral sequence of development. But the exception to this was the diapophyses of the sacral vertebra, whose ossification took place earlier than those of the last four presacrals (i.e., V to VIII vertebra). This owes to the fact that, the larva during these stages (26 to 46) of development prepares itself for a change of mode of life, with a change from swimming to a sitting posture, which requires firm attachment of sacral diapophyses with the ilium of pelvic girdle.

Acknowledgements

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APPENDIX 1
LIST OF ABBREVIATIONS USED

CDP- cartilaginous diapophyses; CE- centrum; CUR- cartilaginous urostyle; DP- diapophyses; NA- neural arch; NCA- neural canal; NS- neural spine; ODP- ossification in diapophyses; OSVE- ossification in sacral vertebra; OUR- ossification in urostyle; OVE- ossification in vertebra; POZ- post zygapophysis; PRZ- pre-zygapophysis; SVE- sacral vertebra; UR- urostyle; VC- vertebral cartilage; VE- vertebra and ZP- zygapophysis process.

Notes on the *Hemidactylus bowringii* complex (Reptilia: Gekkonidae) in India, and a change to the national herpetofaunal list

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(with four text-figures)

ABSTRACT.– The status of *Hemidactylus bowringii* group geckos in India is reviewed and reconsidered in light of recent taxonomic changes and new material from north-east India. Historical records of "*H. bowringii*" document this gecko's occurrence in Andhra Pradesh, Uttarakand, Bihar, West Bengal, Sikkim, Meghalaya, Manipur and Assam. We here report new records from Assam, where it occurs primarily as a house gecko. An evaluation of external morphology suggests that Indian geckos of this group are referable to *H. aquilonius*, originally described from Kachin, Myanmar. This determination is also consistent with the known distribution of the species of the *H. bowringii* group. We, therefore, advocate the removal of *H. bowringii* sensu stricto, now restricted to southern China and adjacent areas, from the Indian herpetofaunal species list and the addition of *H. aquilonius* to it.

KEYWORDS.– *Hemidactylus bowringii*, *Hemidactylus aquilonius*, India, Assam, distribution.

Introduction

North-eastern India, a part of the Indo-Burma biodiversity hotspot, supports a rich assemblage of herpetofauna, with more than 272 species known from the region. The faunal composition is particularly interesting as it is located at a confluence of Indo-Chinese, Indo-Malayan and Indian biogeographic regions (Ahmed et al., 2009). Nonetheless, North-eastern India is arguably one of the most poorly surveyed regions in tropical Asia, especially with regard to its herpetofauna. Few published records are available on lizard diversity, which includes 44 documented species (Gogoi et al., 2001; Ahmed et al., 2009). The genus *Hemidactylus* (Oken, 1817), the second most species-rich genus of gekkonid lizards, is represented by 100 species worldwide (Uetz, 2009). The occurrence of seven species of *Hemidactylus* was reported from the north-eastern states of India (Ahmed et al., 2009), namely, *H. frenatus* (Schlegel, 1836), *H. brookii* (Gray, 1845), *H. bowringii* (Gray, 1845), *H. garnotii* (Duméril and Bibron, 1836), *H. platyurus* (Schneider, 1792), *H. flaviviridis* (Rüppell, 1835), and *H. karenorum* (Theobald, 1868). Except for *H. karenorum*, the presence of which in India has been called into question (see Mahony and Zug, 2007), all of these were encountered during this study.

A recent molecular phylogenetic study of *Hemidactylus* (Carranza and Arnold, 2006),

demonstrated that *H. bowringii*, which has a broad, but patchy distribution from Nepal to the Ryukyus (Zug et al., 2007), exhibits relatively deep genetic divergence between populations. A subsequent study, focused specifically on the *Hemidactylus bowringii* complex (McMahan and Zug, 2007), confirmed that the topotypical population of this species from Hong Kong, is specifically distinct from more western populations previously assigned to *H. bowringii*. McMahan and Zug (2007) suggested that *H. bowringii* sensu stricto occurs from eastern Indochina through southern China to Taiwan and the Ryukyus. They further resurrected the name *H. berdmorei* (Blyth, 1853) for populations from southern Tanintharyi State, Myanmar and they erected two new species, *H. aquilonius* (McMahan and Zug, 2007) and *H. thayene* (McMahan and Zug, 2007), for geckos of the *bowringii* complex occurring in northern Myanmar and adjacent Yunnan and southern Myanmar, respectively.

McMahan and Zug (2007) did not discuss specimens or comment on the taxonomic status of *H. bowringii* complex populations occurring to the west of Myanmar. It is probable on biogeographic grounds that Indian populations of the *H. bowringii* complex are not assignable to either *H. bowringii* sensu stricto from southeastern China or *H. berdmorei* from extreme southern Myanmar, the two names that have historically been employed for them (see synonymies in Boulenger, 1885, 1890; Smith, 1935). Thus, the specific allocation of these populations remains in question. In this paper, we review previous Indian records of "*H. bowringii*", present new records for these geckos from Assam state, and provide a preliminary assessment of the specific allocation of north-east Indian "*H. bowringii*" based on morphological data.

Materials and Methods

We collected specimens from residential areas of three districts of the state of Assam, namely Kamrup, North Lakimpur and Sonitpur. Only photographs were taken of specimens from Nagoan district [ZRC(IMG).2.99a–b]. Specimens were euthanized and stored in 10% formaldehyde solution. Detailed structure of the hemipenis was studied after eversion by injection of 10% formaldehyde. Measurements were taken on voucher specimens using Mitutoyo dial calipers. All the measurement are in mm. The following mensural and meristic characters were recorded: SVL= Snout-vent length, HL= Head length, HW= Head width (at angle of jaw), IND = Internarial distance, MNT = Mental scale length, PMI = Inner postmental scale length, PMO= Outer postmental scale length, AG = Axilla to groin length, FLL = Forelimb length, HLL = Hind limb length, SLB= Supralabial scales, ILB = Infralabial scales, F4L = Fourth finger lamellae, T4L = Fourth toe lamellae. Acronyms used in this paper are: AMNH = American Museum of Natural History, New York; MNHG= Muséum d'Histoire Naturelle, Genève; ZRC = Zoological Reference Collection in the Raffles Museum of Biodiversity Research, National University of Singapore; ZSI = Zoological Survey of India, JP = Jayaditya Purkayastha (personal collection).

Results

Distribution.– Smith (1935) gave the general distribution of *Hemidactylus bowringii* as India (including Chittagong, now in Bangladesh), 'Burma' (now Myanmar) and China. Subsequent Southeast Asian records have been reported from Laos (Bourett, 1939) and Vietnam (Bobrov 1992), and the species complex as a whole is now known to have a broad distribution across much of tropical and subtropical Asia (Zug et al., 2007; McMahan and Zug, 2007). The earliest Indian records are from Stoliczka (1871), who listed localities for *H. berdmorei* (sic) as "Burma, Cachar, Sikkim Terai, Tista Valley and Kumaon." In a subsequent, more extensive version of the paper (Stoliczka, 1872), the Indian localities were recorded somewhat differently as "Khasi Hills" (Assam, now in Meghalaya), "Pankabari just above the Sikkim Terai" (Sikkim), and "Almorah, in Kamaon" (now Kumaon in Uttarakhand). Boulenger (1885) noted specimens from "Godavery" collected by W.T. Blanford, and later (Boulenger, 1890) gave the distribution as "Eastern India (Sikhim and ? Godávari Valley)".

The presence of *H. bowringii* in Sikkim has recently been confirmed by Jha and Thapa (2002) and Chettri and Bhupathy (2007), although Sanyal et al. (2006) did not include it in their list for the region. Barbour (1912) noted

specimens from the "valley of the Teesta River in the border of Bhutan" and Smith (1935) explicitly mentioned Darjeeling as a locality. Other vouchered records from West Bengal include "Teesta P.W.D. Bungalow, Jalpaiguri District" and "Jarkhoala, Dist, Darjeeling" (Ahmed and Dasgupta, 1992). A specimen from Calcutta (MHNG 742.086) is present in the collections of the Muséum d'Histoire Naturelle, Genève as retrieved from their online collection database.

Tikader and Sharma (1992) and Sharma (2002) mapped *H. bowringii* as widespread in Andhra Pradesh, apparently on the basis of the Godávari record. Sanyal et al. (1993), however, reported specimens from Dorsi and Poddile in the Prakasam District of Andhra Pradesh, providing the first vouchered records from precise localities in the state. The Kumaon locality may be questioned as being further west than may be anticipated and, unfortunately, the specimen(s) upon which this record and Stoliczka's other "*H. berdmorei*" records are based, appear to be untraceable (Blanford, 1876). However, there are modern records from the Nepalese Terai and Almorah is close to one of these, in the Godha Godhi Valley in far western Nepal (Kästle, 2002). There appear to be no more recent records from Uttarakhand, but a specimen from "Kolassy, Purnea" (now Purnia), Bihar based on a specimen collected in the 19th century by John Anderson, but not previously published (Dasgupta and Raha, 2004), helps to fill the distributional gap between Kumaon and Bengal records.

In north-east India, the first new record after Stoliczka's (1872) mention of the Khasi Hills was that of Annandale (1912), who noted that *H. bowringii* as "not uncommon at low altitudes in the eastern Himalayas and in Assam and Burma" and cited a specimen from Sadiya in the Tinsukia District of Assam. This was followed by Baldauf's (1949) record of a single vouchered specimen (AMNH 67611) from "Chabua" near Dibrugarh city, Jorhat District (now in Dibrugarh District). Although *H. bowringii* has since been included in the lists of the Assamese fauna (Sengupta, 2006), there have been no further published records of specific localities and some works (Tikader and Sharma, 1992; Sharma, 2002) do not even include north-east India in the range of the species. In our study, we found this lizard in four other dis-

tricts of Assam: Kamrup, Nagoan, Sonitpur and North Lakhimpur. Most of the specimens were collected from Guwahati, (Kamrup District and two of those specimens are deposited to ZSI, Shillong (VR/ERS/ZSI/414–415). The specimens from Guwahati were collected from Kamakhya (Nilachal Hill), Assam State Zoo cum Botanical Garden, Sukreshwar Park and Nehru Park, and the areas of Lachitnagar and Lalganesh. A total of 26 specimens were collected and served as the basis for our morphological analysis. In addition, a specimen in the collection of the ZSI, Shillong (ERS 1234) establishes the presence of the species from the neighboring state of Manipur (Moirang, Bishnupur). Precise records from other north-east Indian states are lacking, but it is probable that "*H. bowringii*" is much more widespread in the region than previously recognized. Localities that are vouchered or mentioned in the literature are shown in Figure 1.

Description.– Of the 26 specimens collected, nine were male and the rest female. Mensural and meristic data are presented in Table 1. SVL for the sample ranged from 37.5 to 56.2 mm ($\bar{x}$ = 46.46 + 0.786 mm). The dorsum and tail are devoid of enlarged tubercles, original tails are verticillate. Toes moderately dilated, with lamellae beneath the fourth finger 7–9 ($\bar{x}$ = 8.19 + 0.111), and fourth toes 9–12 ($\bar{x}$ = 10.42 + 0.138), respectively. Supralabial scales 9–12 ($\bar{x}$ = 10.5 + 0.186), infralabial scales 8–10 ($\bar{x}$ = 8.5 + 0.114). The average size of the inner postmental (1.2 + 0.044 mm) is about 1.7 times the average size of the outer (0.65 + 0.028 mm). The posterior edges of the inner postmentals are convex. In some cases, the second postmentals are fragmented. In all cases the inner pair of postmentals touch medially, which is never the case for the outer pair (Fig. 2). Precloacal pores present in males only in a series of 23–28 ($\bar{x}$ = 26.3 + 0.62), interrupted medially, usually by 2–4 poreless scales.

In its dark phase, the lizard exhibits one pair of interrupted, brown dorsolateral stripes from the occiput to the sacrum, paralleling an irregular cream vertebral stripe. Across the middorsum and extending laterally to the dorsolateral stripes are a series of 7–8 narrow, brown, posteriorly-directed chevrons. On original tails, a series (usually 12–13) of small dark brown
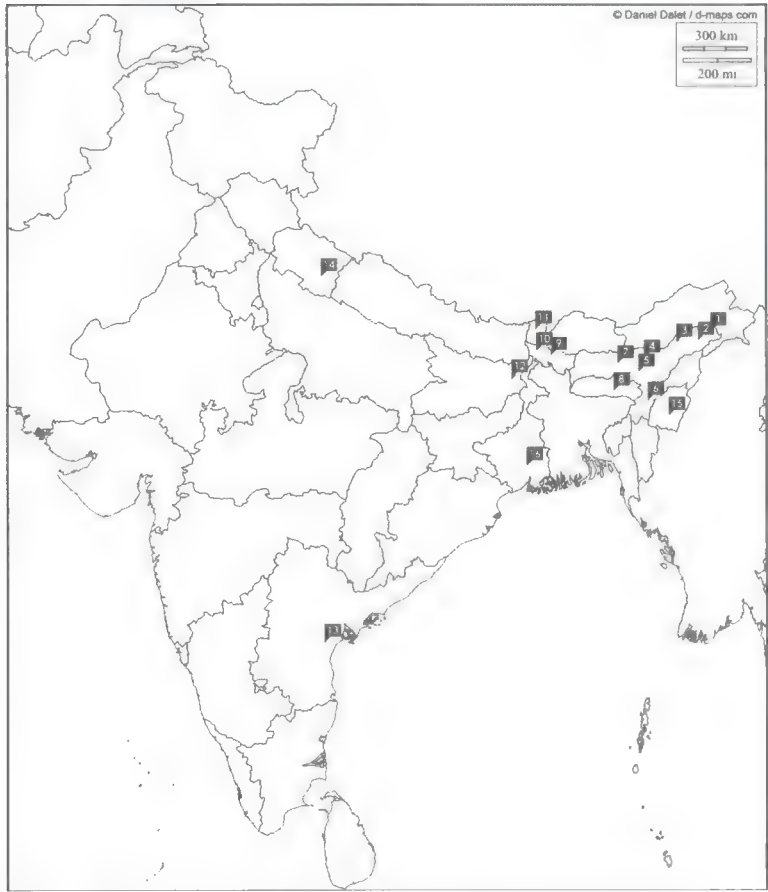
Figure 1. Map showing distribution of *H. bowringii* group geckos in India Places marked on the map. 1: Tinsukia (Assam), 2: Dibrugarh (Assam), 3: North Lakhimpur (Assam), 4: Sonitpur (Assam), 5:Kamrup (Assam), 6: Cachar (Assam), 7: Nagaon (Assam), 8: Khasi hills (Meghalaya), 9: Jalpaiguri (West Bengal), 10: Darjeeling (West Bengal), 11:Sikkim Terai (Sikkim), 12: Purnia (Bihar), 13: Prakasam (Andhra Pradesh), 14: Kumaon (Uttarakhand), 15: Bishnupur (Manipur), 16: Kolkata (West Bengal). Base map courtesy of d-maps.com.

the naris, through the eye, to the insertion of the hind limb (Fig. 3).

The hemipenis is bilobed and elongate. Its trunk is long and ends in a voluminous bilobed head covered with numerous small papillae. The sulcus spermaticus is bifurcated and passes around to the asulcal surface before entering the head of the lobes. The region of bifurcation of the sulcus spermaticus is almost a third of the total length of the hemipenis, which is totally devoid of other ornamentation on its trunk or pedicel (Fig. 4).

Natural History.– Like most geckos, this lizard was seen to be more active after dusk. Most of the specimens were collected in urban settings from Guwahati, a city with a human population of over 800,000. The lizards in this area were always encountered in and around human habi-

cross markings alternate with much larger, irregularly-defined areas of cream colour. A whitish to cream stripe, often interrupted, runs from
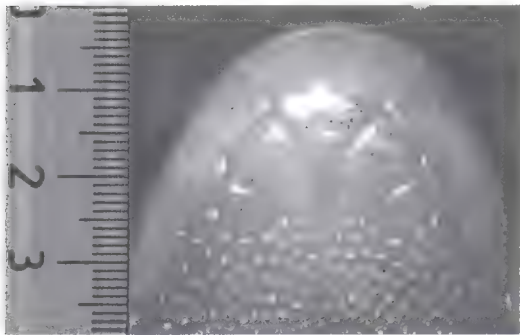
Figure 2. Chin scale arrangement of *H. aquilonius* (JP0089) from Assam. Scale in mm

tation, living in sympatry with *H. frenatus* and *H. brookii*. We found them mostly on the walls of the houses near incandescent lights where arthropod prey was abundant. McMahan and Zug (2007) also reported that the *H. bowringii* group from Kachin State (Myanmar) and Yunnan were house geckos, whereas Annandale (1912) found them more common in jungle than around human habitations in north-east India. We never encountered this gecko beneath leaf litter as reported by Zug et al. (2007) in the Saigain Division of Myanmar. A single gravid female was collected in November.

Discussion

According to McMahan and Zug (2007), the *H. bowringii* complex comprises *H. bowringii*, *H.*

Table 1. Mensural and meristic characters of *Hemidactylus aquilonius* from Assam. Abbreviations as indicated under Methodology.

Specimen	Locality	Sex	SVL	HL	HW	IND	AG	FLL	HLL	MNT	PMI	PMO	SLB	ILB	F4L	T4L
JP0028	Guwahati	M	47.4	8.3	8.6	1.3	21.0	17.0	20.0	1.6	1.1	0.7	11	8	9	11
JP0029	Guwahati	M	56.2	8.4	9.7	1.7	24.8	19.0	21.0	2.1	1.3	0.8	12	9	8	11
JP0030	Guwahati	F	42.4	7.2	8.4	1.0	17.5	15.0	19.0	1.7	1.1	0.6	10	9	9	11
JP0032	Guwahati	F	44.8	8.1	8.3	1.2	21.1	15.0	17.0	1.6	1.8	0.6	11	8	8	10
JP0033	Guwahati	F	45.8	7.2	7.9	1.2	21.3	15.0	18.0	2.0	1.0	0.6	10	9	8	11
JP0035	Guwahati	M	47.3	7.8	9.2	1.2	21.3	17.0	19.0	2.0	1.1	0.6	10	9	8	10
JP0038	Guwahati	M	47.6	8.1	8.0	1.2	20.4	17.0	18.0	2.0	1.4	0.6	12	9	8	10
JP0039	Guwahati	F	49.2	8.6	8.6	1.4	21.4	17.0	21.0	2.0	1.5	0.8	10	8	8	11
JP0043	Guwahati	M	42.4	7.6	7.5	1.3	17.6	13.0	18.0	1.6	0.9	0.4	11	9	8	10
JP0050	Guwahati	F	42.8	7.2	7.6	1.1	17.4	16.0	17.0	2.0	1.1	0.6	10	8	8	11
JP0049	Guwahati	F	44.0	7.7	7.8	1.4	18.5	16.0	18.0	1.8	1.1	0.6	9	8	8	11
JP0051	Guwahati	F	43.5	7.1	7.4	1.2	19.8	17.0	19.0	1.6	1.3	0.8	9	8	8	10
JP0108	North Lakhimpur	F	45.6	7.1	7.8	1.3	22.7	15.0	19.0	1.8	1.2	0.6	11	8	8	10
JP0109	Sonitpur	M	45.8	8.3	8.8	1.5	19.3	16.0	21.0	1.8	1.2	0.6	11	10	8	11
JP0088	Guwahati	M	48.6	8.1	8.2	1.7	21.4	16.5	21.8	1.7	1.4	0.6	11	8	8	10
JP0047	Guwahati	M	51.2	9.3	9.4	1.7	24.3	17.4	22.0	2.1	1.5	1.1	10	8	7	9
VR/ERS/ ZSI/415	Guwahati	F	40.4	6.7	8.0	1.2	16.5	15.0	18.7	1.6	1.4	0.6	12	9	8	9
JP0089	Guwahati	F	48.5	7.7	8.4	1.6	21.7	17.0	20.6	2.0	1.0	0.6	12	9	8	11
JP0046	Guwahati	F	45.2	8.7	8.9	1.4	19.4	14.9	18.0	1.6	1.4	0.8	9	8	7	10
JP0083	Guwahati	F	45.2	7.9	7.8	1.8	20.6	15.2	20.2	1.8	0.7	0.6	9	9	9	11
JP0086	Guwahati	F	37.5	6.2	7.0	1.4	15.5	13.0	15.5	1.5	1.1	0.4	10	8	9	10
JP0085	Guwahati	F	47.4	8.5	8.4	1.15	19.8	16.1	21.2	1.6	1.0	0.5	11	9	8	10
JP0090	Guwahati	F	49.3	8.3	8.4	1.4	24.7	15.3	19.7	1.6	1.2	0.8	10	9	9	12
JP0091	Guwahati	F	50.3	8.3	8.4	1.35	21.9	16.6	20.3	2.0	1.3	0.6	11	8	9	10
JP0092	Guwahati	F	45.6	8.2	8.5	1.6	20.8	15.7	19.7	1.7	1.2	0.8	10	8	8	10
JP0105	Guwahati	M	53.9	8.5	8.7	1.9	25.8	17.2	23.2	2.1	1.0	0.7	11	8	9	11
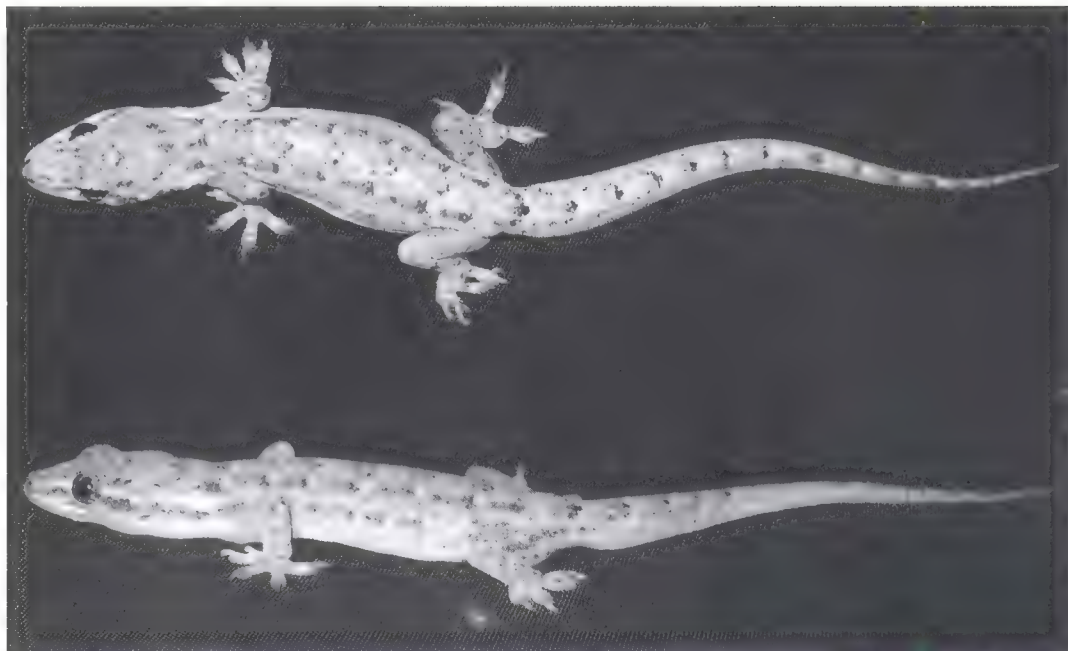
Figure 3. Dorsal (above) and lateral (below) views of living *Hemidactylus aquilonius* (JP0051) from Guwahati, Assam.

berdmorei, H. aquilonius and *H. thayene*. All members of this group are similar morphologically and the majority of mensural and meristic characters show broad overlap between species. The question of specific identity is further complicated by the fact that the name *H. berdmorei* (Blyth, 1853) is based on a now disintegrating holotype and so cannot be reliably characterized or compared to other named members of the *bowringii* group (McMahan and Zug, 2007).

Specimens from Assam reach an SVL of at least 56.2 mm. This is well above the maximum size given by McMahan and Zug (2007) for *H. thayene* (44 mm) and substantially larger than that for *H. bowringii* (47 mm; although Lazell, 2002, reported specimens as large as 54 mm from Hong Kong). The SVL of the largest specimen (JP0029) is nearly identical to that of the largest *H. aquilonius* and to the estimated SVL of the type of *H. berdmorei* 56 mm (McMahan and Zug, 2007). Assamese specimens differ from *H. thayene* in having a convex (versus straight) posterior edge to the first and second postmentals (Fig. 2) and in exceeding (in some individuals) the reported number of precloacal pores in this species (18–26; McMahan and Zug, 2007). They differ from *H. bowringii* in possessing an interrupted dorsolateral stripe (versus continuous) and irregular dark dorsal markings (versus chevrons) on the tail. In these regard, the colour pattern, postmental shape, and precloacal pore counts of our
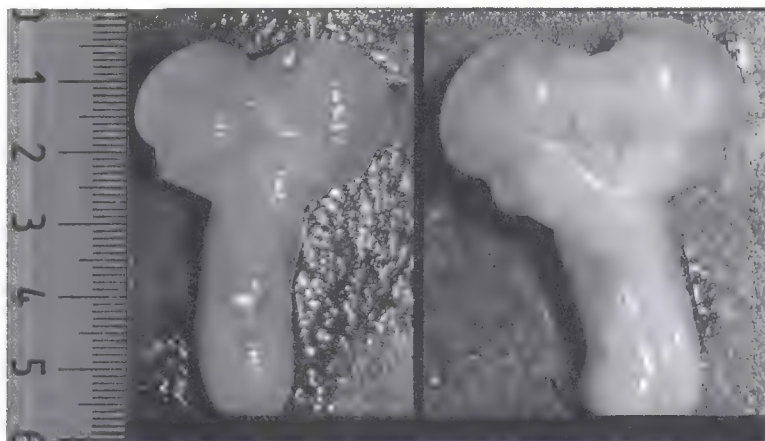
Figure 4. Asulcal (left) and sulcal (right) views of the hemipenis of *H. aquilonius* (JP0105) from Assam. Scale in mm

specimens are consistent with those of *H. aquilonius*. Further, the type locality of *H. aquilonius* in Kachin State, Myanmar, is relatively close to the north-eastern India, and one published locality for this species is immediately adjacent to the border of Arunachal Pradesh, whereas the distribution of *H. bowringii* is in east and southeast Asia (McMahan and Zug, 2007). Thus, on both morphological and biogeographic grounds it seems apparent the *Hemidactylus aquilonius* is the most likely of the described members of the group to occur in Assam and adjacent regions of north-east India. The poor condition of the type of *H. berdmorei* and the lack of recent material from its type locality in extreme southern Myanmar preclude any meaningful comparison with this form, but the large geographic disjunction (occupied by both *H. thayene* and *H. aquilonius*) between Tanintharyi State and Assam argues against their being conspecific. The possibility that Indian populations represent one (or more) undescribed species in the *H. bowringii* complex also exists, but cannot at present be tested. Given the morphological conservatism of the group, it would appear that a molecular approach to this problem would be most useful. This will, however, require sampling throughout Uttar Pradesh, Bihar, Orissa, and Andhra Pradesh, as well as West Bengal, Sikkim, and north-east India in order to determine if all Indian populations' members are conspecific. Further, topotypical *H. berdmorei* from Myanmar will also be required in order to stabilize the application of that name. In the meantime, we believe from the existing evidence that *H. bowringii* sensu stricto does not occur in India, is incontrovertible. On the other hand, data currently available support the hypothesis that Assamese (and presumably other Indian populations) of this species complex are assignable to *H. aquilonius* and, pending future research, we advocate the removal of the former and the addition of the latter species to the national herpetofaunal list.

Acknowledgements

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Amphibians of some protected landscape of Assam, North-eastern India

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(with one text figure)

ABSTRACT.– Spatial distribution of the amphibian fauna of some protected landscapes of Assam State, India, was studied. A total of 57 species of amphibians were recorded, with Nameri-Pakke landscape being the most species-rich region. Further, it was observed that Nameri-Pakke, Dihing-Patkai and Nambor-Doigurung-Garampani landscapes exhibit high similarities due to similarity of forest type, habitat conditions, and latitudinal proximity. The protected landscapes suffer from various scales of human interference. The threats to the amphibian, as currently perceived, include destruction of habitat through felling, collection of forest produce, extraction of rocks, oil exploration, human encroachment, and collection of amphibians for consumption. These factors may be causal for the severe depletion of amphibian populations in various protected landscapes within Assam State.

KEY WORDS.– Amphibians, protected landscapes, conservation, Assam, India.

Introduction

The State of Assam is the centre of attention as an area of global importance, due to its rich biodiversity, representing a unique physiographic makeup characterized by hills, plateau and flood plains. The hills are extensions of the Himalayan range, and of Recent (Tertiary) formation. The Karbi Anglong region, a part of the Assam-Meghalaya Plateau, is composed of the oldest rocks, being of Precambrian origin. The plains, namely, Brahmaputra and Barak, are of tectonic origin, and house large quantities of sediments, from Tertiary times to present.

Despite being known as part of the twin biodiversity hot spots, namely the Eastern Himalaya and Indo-Burma, the amphibian fauna of Assam remain poorly known, and most of the records are that of undivided Assam of India's pre-independent period (that is, prior to 1947, when most of the states of north-eastern India were under Assam state). The present conservation status of the region's amphibian species remain unknown (including *Gegeneophis fulleri*, *Rhacophorus tuberculatus*, etc.). In recent years, some of areas have been inventoried (see Pathak et al., 2001, Choudhury et al., 2001, Sarma et al., 2007), and new species have been described (Dutta et al., 2000, Das et al., 2004, Bordoloi et al., 2007, Sengupta et al., 2008). The aim of the present study is to describe spatial characteristics of amphibian communities of selected protected landscapes of the region.

Materials and Methods

The study was carried out from 2003 to 2006 in the following areas, representing different ecosystems- Pabitora Wildlife Sanctuary (savannah grassland); Dihing Patkai Wildlife Sanctuary, Innerline Reserve Forest, Forests of Barak Valley Landscape (moist tropical ever-
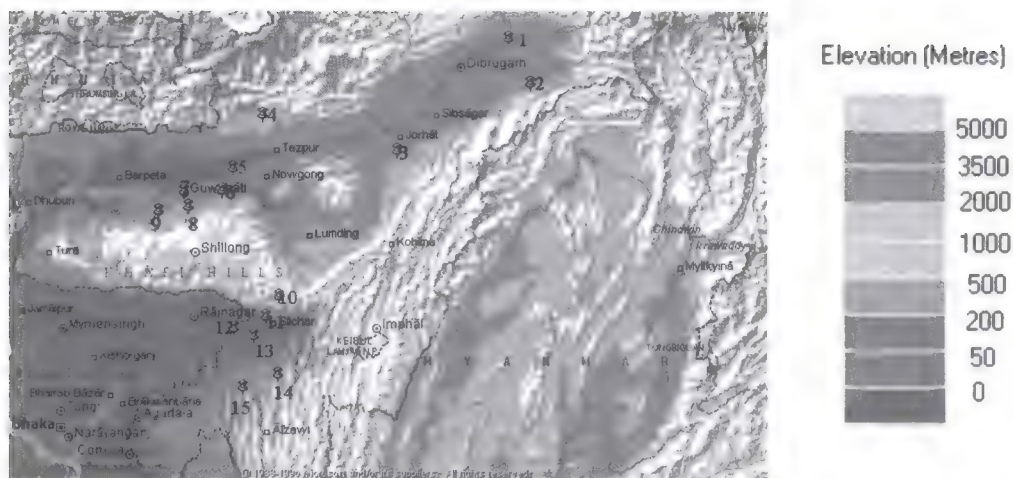
Figure 1. Map of study areas in Assam State, north-eastern India. Reference: 1. Borjan-Bherjan-Padumoni Wildlife Sanctuary, 2. Dihing Patkai Wildlife Sanctuary, 3. Garampani-Nambor-Doigurung landscape, 4. Nameri landscape, 5. Pabitora Wildlife Sanctuary, 6. Garbhanga RF, 7. Deepor Beel, 8. Rani RF, 9. Kulsi RF, 10. North Cachar R.F. 11. Singla, 12. Tilbhum R.F., 13. Badsahitilla, 14. Innerline R.F. and 15. Longai R.F.

green forests); Garampani-Nambor-Doigurung Landscape, Nameri Landscape (tropical semi evergreen forest); Kholaghat Reserve Forest (R.F.) and Rani R.F. (tropical moist deciduous forest); Beel (fresh water ox-bow lake; Son and Deepar; littoral and swamp forest); Kulsi R.F. (tropical sal forest). Amphibians were collected by searching in specific microhabitats along transects, such as from the leaf litter, under logs, rock crevices, tree holes, etc. Natural history notes were taken, and the threats to amphibian fauna were recorded through interview of forest and forest fringe settlers. Pitfall traps were laid specifically near waterholes. Amphibians were identified following standard keys and monographs, and whenever possible, through comparisons with the types and voucher specimens in the Zoological Survey of India, Kolkata (ZSIC), Zoological Survey of India, Shillong (ZSIS), and Arya Vidyapeeth College Museum (AVCM). All specimens collected were deposited in the AVCM. Similarity among communities was calculated as coefficient of communities, using formula of Whitaker (1970).

Results and Discussion

In the present investigation, 56 species of anurans and one species of caecilian were recorded (Table I). The records of amphibians of different protected areas are as follows:

Pabitora Wildlife Sanctuary.– Pabitora Wildlife Sanctuary is in the Brahmaputra flood plain and is composed mainly of grassland (68%) and swampy area (25%). A total of 12 species of amphibians (Bufonidae: one species, Microhylidae: one species, Rhacophoridae: one species, Dicroglosidae: six species, Ranidae: three species) were recorded. *Hylarana tytleri* was observed amongst aquatic vegetation of the beel ecosystem and *E. cyanophlyctis* was found the most abundant species of the area.

Dihing-Patkai-Joypur landscape.– This area is mainly composed of moist tropical evergreen forest (dipterocarp) with a number of waterholes, small nullahs and streams cutting across the Sanctuary. High humidity and heavy rainfall are significant features of the area. The Sanctuary supports a rich amphibian fauna. In the present study, one species of the family Bufonidae, one of Megophryidae, one of Microhylidae, four species of Ranidae, eight species of Dicroglossidae and 11 species of Rhacophoridae were observed. An endemic species, *Philautus namdaphaensis,* was found, and the occurrence of *Chiromantis nongkhorensis* comprises the first country record.

Innerline R.F.– This R.F., situated in southern Assam, at the Assam-Mizoram border, is composed of many varieties of deciduous and evergreen trees including bamboo and dipterocarps. A total of 24 species of amphibians (Megophryidae: one species, Bufonidae: one species, Microhylidae: four species, Rhacophoridae: five species, Dicroglossidae: eight species, Ranidae:

Table 1. Amphibian species recorded from the study areas in Assam State, eastern India.

Species	Microhabitat	IUCN status	Remarks
Xenophrys parva	moist leaf litter	LC	rare, Rani- Garbhanga Landscape
Xenophrys wuliangshanensis	moist leaf litter, forest path	DD	rare, new record for Assam
Leptobrachium smithi	leaf litter, moist crevices of rocks	LC	common, south of Brahmaputra
Duttaphrynus melanostictus	damp places, inside holes, under logs, near human habitation, etc.	LC	common, widely distributed
"Bufo" stomaticus	moist and shady closed places such as under logs and stones	LC	uncommon, north of Brahmaputra
Kaloula assamensis	loose, moist soil. Calling male on herbaceous vegetation	DD	rare, north of Brahmaputra
Kaloula pulchra	degraded evergreen forest edges, in ponds with extensive aquatic vegetation, herbaceous vegetation and tree trunk	LC	common, southern Assam (but absent in Brahmaputra valley)
Microhyla berdmorei	leaf litter and moist grass near stream	LC	common, hilly tracts
Microhyla ornata	leaf litter and in amongst moist herbaceous vegetation	LC	common, widespread
Microhyla heymonsi	forest floor of fairly dense secondary growth near small water channels	LC	rare, Innerline R.F.
Uperodon globulosus	fossorial, common in loose, moist soil, especially arum growing areas	LC	uncommon, north bank of Brahmaputra
Aquixalus naso	on saplings and bushes in evergreen forests, 1–1.7 m	DD	uncommon, isolated hills and plains
Rhacophorus bipunctatus	evergreen to semi-deciduous moist forest, on tree branches or on lianas, 3–5 m	LC	common, widely distributed in all woodland forests
Rhacophorus maximus	dense wooded tropical evergreen and semi-evergreen forests, arboreal over 2.5 m	LC	common, widely distributed in all the woodland forest areas of hills and plains
Rhacophorus rhodopus	hilly terrain, on trees growing near streams, 0.91–1.52 m	DD	rare, Nameri and Dihing Patakai Landscape
Polypedates leucomystax	variable habitat needs; more abundant around human habitations	LC	common and widely distributed
Polypedates sp. 1	leaf litter and foam nests observed amongst moist leaf litter in shallow water	–	common, evergreen to deciduous forest floor of western and southern Assam
Chiromantis nongkhorensis	bushes in moist evergreen forest	LC	rare, a new record for India
Chiromantis simus	moist grass land, herbaceous vegetation	LC	uncommon and patchy in western and southern Assam
Chiromantis vittatus	evergreen and semi evergreen forests	LC	common and continuously distributed in western, central and southern Assam
Philautus andersoni	bushes of evergreen forests, about 1.7 m.	LC	rare, upper stretch of Nameri landscape
Philautus annandalii	bushes, 1.6 m in moist evergreen forests, 140 m	LC	rare, upper stretch of Nameri landscape
Philautus garo	bushes of moist deciduous forests, 0.25–0.5 m	VU	north-east endemic, common
Philautus namdaphaensis	bushes in moist humid evergreen forests	DD	rare; record from outside type locality
Philautus parvulus	lianas, bushes and saplings in semi-evergreen to moist deciduous forests	LC	common, with other congeneric species
Euphlyctis cyanophlyctis	aquatic, mostly in shallow water	LC	common; represented by various morphological types
Fejervarya pierrei	moist leaf litters of woodland, moist grassland and open field including cultivated land	LC	common in all study sites

Fejervarya nepalensis	open land with moist grasses and herbs near water	LC	common in all study sites
Fejervarya syhadrensis	wide range of habitat, from thick forests to human habitations, frequently near water, also moist areas away from water	LC	common in all study sites
Fejervarya teraiensis	flooded paddy fields; vicinity of temporary or permanent water bodies	LC	common in all study sites
Limnonectes laticeps	semi-aquatic, small hilly streams in evergreen to moist deciduous forests with overhanging vegetation, 80–235 m	LC	common in hilly streams
Hoplobatrachus crassus	pond, ditches, water logged agricultural fields	LC	uncommon; disturbed areas of Brahmaputra flood plains
Hoplobatrachus tigerinus	wetlands, abundant in partially disturbed areas	LC	common in flood plains of Brahmaputra and Barak
Hylarana taipehensis	flooded agriculture field, on grass blade vertically, on leaves of water hyacinth; frequently on land with moist grass	LC	common in flood plains of Brahmaputra and Barak
Hylarana tytleri	sympatric with H. taipehensis	LC	common in flood plains of Brahmaputra and Barak
Hylarana leptoglossa	thick vegetation near wetland or vegetation mounds of submerged field	LC	common in undisturbed and disturbed areas
Humerana humeralis	water-logged areas, wet grasslands, sometime on bare earth, climbs trees, especially during floods	LC	abundant in flooding-prone plains
Nasirana alticola	stream, moist crevices of rocks, moist rock cliff	LC	common stream frog of hilly terrain
Amolops assamensis	fast-flowing streams, splash-zone of dark, moist rock crevices, with overhead canopy cover in fast flowing streams of moist deciduous forests	-	rare, north-east endemic reported from Khasi-Garo foot hills
Amolops gerbilus	fast-flowing streams, in rock crevices of moist evergreen patches	LC	rare, evergreen forests at mid altitude
Amolops marmoratus	hilly stream and waterfalls with rocky base, in rock crevices near streams in moist deciduous to semi-evergreen forest	LC	common cascade frog of low to mid altitude forest streams
Amolops formosus	fast-flowing hill streams with canopy		uncommon, moist evergreen forest at upper reach of Nameri-Pakke landscape
Amolops aff. viridimaculatus	fast-flowing stream with total canopy		Rare, moist evergreen forest at upper reach of Nameri-Pakke landscape
Occidozyga borealis	hill stream seepages	VU	common, northern, central and southern Assam
Pterorana khare	streams in evergreen forests	VU	rare, north-east endemic
Ichthyophis garoensis	moist leaf litter on rocky substratum	DD	Foot hills of Khasi _ Garo Hills
Amolops sp. 1	fast-flowing streams	-	only North Cachar Reserve Forest (Karimganj)
Amolops sp. 2	fast flowing stream, on moist shady rocks		rare, moist evergreen forest at upper reach of Nameri-Pakke landscape.
Xenophrys sp. 1	moist leaf litter near fast flowing stream	-	Rani-Garbhanga Landscape
Xenophrys sp. 2	moist leaf litter in evergreen forest floor	-	North Cachar Reserve Forest (Karimganj)
Xenophrys sp. 3 (small)	leaf litter near fast flowing hill stream, thick canopy cover	-	Upper stretches of Nameri Pakke landscape
Xenophrys major	small stream near road sitting on moist algae coated rocks.		rare, moist evergreen forest at upper reach of Nameri-Pakke landscape

Xenophrys minor	fast flowing hill stream with thick canopy; single specimen on moist shady rock below shrub	Upper stretches of Nameri Pakke landscape in moist evergreen forest
Nanorana liebigii	narrow stream with seeping water in moist evergreen forest	Upper stretches of Nameri Pakke landscape
Nanorana sp.	stagnant pools of water in moist evergreen forests	upper stretches of Nameri Pakke landscape
Polypedates sp.	saplings and trees of moist evergreen forests	Nameri Pakke landscape
Bufo aff. *cyphosus*	moist open areas	upper stretches of Nameri Pakke landscape

five species) were observed. The notable species were *Microhyla heymonsi*, *M. berdmorei*, *Chiromantis vittatus*, *Limnonectes laticeps*, *Occidozyga borealis* and *Kaloula pulchara*

Garampani-Nambor-Doigurung landscape.– The landscape is represented by the twin sanctuaries of Garampani and Nambor-Doigurung, situated in the districts of Golaghat and Karbi Anglong of Assam. The area encompasses 14 km² and is tropical semi-evergreen. A total of 22 species (Megophryidae: one species, Bufonidae: one species, Microhylidae: one species, Rhacophoridae: nine species, Dicroglossidae: eight species, Ranidae: two species) were recorded. A species morphologically similar to *Chiromantis simus* was recorded from this area, which is unique for its larger size (SVL ♀ 30.70 and ♂ 37.40 mm, respectively), and was observed in the vicinity of a hot spring, on trees with lianas. Other notable species documented were *Aquixalus* cf. *naso*, *Philautus parvulus*, *Chiromantis vittatus* and *Occidozyga borealis*.

Nameri landscape.– Nameri National Park in Assam and Pakke Wildlife Sanctuary in Arunachal Pradesh together form a continuous landscape, within the boundaries of eastern Himalayas and are here referred to as the Nameri landscape. The vegetation in the area is a mosaic of tropical semi-evergreen and evergreen types, largely corresponding to the Assam valley tropical semi-evergreen forest, interspersed with more evergreen patches in moist areas, tending towards sub-tropical broad leaved forests at higher altitude. In all, 40 species of amphibians (Megophryidae: three species, Bufonidae: three species, Microhylidae: three species, Rhacophoridae: 14 species, Dicroglossidae: eight species, Ranidae: nine species) were seen. Rare endemics observed were *Kaloula assamensis,* and *Pterorana khare.* Further unidentified species of *Xenophrys,*

Polypedates, Nanorana and *Amolops* were also recorded from this landscape.

Kholaghat Reserve Forest.– The Kholaghat R.F. is represented by moist deciduous elements and the amphibians recorded include a species of Bufonidae, one of Rhacophoridae, six species of Dicroglossidae and three species of Ranidae. *Amolops assamensis*, a north-east India endemic, was recorded from the stream and tadpoles of the same species were seen to cling to the rocks against the flow.

Rani R.F.– This is a part of Rani-Garbhanga landscape and is situated at the foot hills of Meghalaya plateau, with hilly terrain covered by mixed deciduous and semi-evergreen type with riparian zone along its perennial streams. The landscape is the abode of 23 species of anuran amphibians (Megophryidae: two species, Bufonidae: one species, Microhylidae: two species, Rhacophoridae: four species, Dicroglossidae: seven species, Ranidae: seven species), besides a species of caecilian (Ichthyophidae). *Amolops assamensis, Philautus garo* and *Ichthyophis garoensis* are the north-east endemics, found here.

Son Beel.– This is the largest beel system of Barak drainage in southern Assam, and is represented by a group of 24 smaller beels. Due to siltation, most of the area has become shallow, permitting the cultivation of paddy, and only a small part is perennial. Aquatic macrophytes reported from the beel were *Azolla pinnata, Eichnornia crassipes, Salvinia cucullata, Nelumbo nucifera, Hydrilla ventricillata, Alternantha sessiles, Cyperus platystylis* (Das, 2006). A total of 14 species of amphibians (Bufonidae: one species, Microhylidae: two species, Rhacophoridae: two species, Dicroglossidae: six species, Ranidae: three species) were observed in the area.

Deepor Beel Bird Sanctuary.– This beel is among one of the largest in western Assam.

The aquatic vegetation of the beel includes water hyacinth; aquatic grasses, water lilies and others submerged, emergent and floating vegetation. During the present survey, 16 species of anuran amphibians (Megophryidae: one species, Bufonidae: one species, Microhylidae: two species, Rhacophoridae: two species, Dicroglossidae: six species, Ranidae: four species) were observed. The Ranidae and Dicroglossidae together constitutes more than 54.5% and represented by aquatic species such as *Euphlyctis cyanophlyctis , Hoplobatrachus tigerinus* and semi aquatic species, such as *Hylarana leptoglossa, H. tytleri, Humerana humeralis, Fejervarya teraiensis, F. syhadrensis, F. pierrei* and *F. nepalensis. Hylarana tytleri* is the most dominant species of the beel, inhabiting areas with water hyacinth and moist open land at the shore.

Kulsi (Plantation) Reserve Forest.– The forest type is combination of natural tropical Sal forest, with plantation of teak in patches. In the Reserve Forest, 19 species of anuran (Megophryidae: one species, Bufonidae: one species, Microhylidae: two species, Rhacophoridae: three species, Dicroglossidae: seven species, Ranidae: five species) and one species of caecilian (*Ichthyophis garoensis*) were observed. *Fejervarya teraiensis, Limnonectes laticeps* and *Hylarana leptoglossa* were frequently encountered.

Reserve Forest of Karimganj District.– Seven Reserve forests were surveyed and together considered to represent the Barak Valley landscape, with tropical wet evergreen forest. A total of 27 species of amphibians were found during the present study from the reserved forests (Longai,

Duhalia, Singla, Badsahitilla, Patharia, Tilbhum, and North Cachar) of this landscape.

The similarity in amphibian composition of different habitats was studied in the present investigation. It was observed that Nameri-Pakke, Dihing-Patkai, and Nambor-Doigurung-Garampani exhibit high similarities (Table 2). This is probably due to similar forest type and habitat conditions, and also due to their latitudinal close approximation. However, the amphibian species composition of Innerline and Nameri show less than 50% similarities between them, which may be due to latitudinal differences. The grassland and marshy habitats of all the study sites express higher levels of similarities. The moist deciduous forests of Rani and Kolaghat also do not show much similarity. The study indicates that though the vegetation pattern of areas of importance is similar but due to latitudinal location and different degrees of human interference these areas show differences in composition of amphibians, including rare and endemic species.

Though the study sites are protected areas, various degrees of threat due to human interference were noticed. In Nameri no serious threat against the amphibian was perceived, the ethnic population occasionally found to collect species of *Amolops, Hoplobatrachus* and *Rhacophorus* for local consumption. Cattle grazing in a limited way were observed, along with wild vegetable and crab collection.

Dihing Patkai Wild life Sanctuary is highly diversified and a large number of people daily entered the Sanctuary in search of firewood, wild vegetables, and also for fishing. This area is encircled by tea plantation, and the ethnic tribesmen traditionally practiced sustainable uti-

Table 2. Coefficient of community for amphibians between different study sites in Assam, eastern India.

	Dihing	Nameri	Nambor	Rani	Innerline	Deepor	Son	Pabitora	Kolaghat	Karimganj	Kulsi
Dihing	1.00	0.65	0.71	0.43	0.48	0.45	0.43	0.46	0.37	0.51	0.44
Nameri		1.00	0.51	0.33	0.39	0.33	0.32	0.30	0.24	0.44	0.33
Nambor			1.00	0.44	0.59	0.46	0.50	0.52	0.37	0.59	0.45
Rani				1.00	0.60	0.60	0.46	0.50	0.46	0.54	0.76
Innerline					1.00	0.48	0.52	0.50	0.40	0.76	0.63
Deepor						1.00	0.67	0.75	0.59	0.48	0.72
Son							1.00	0.86	0.67	0.52	0.55
Pabitora								1.00	0.77	0.44	0.60
Kolaghat									1.00	0.36	0.48
Karimganj										1.00	0.62
Kulsi											1.00

lization of forest resources. Increase in population has created pressures on this forest, but encroachment was neither reported nor observed. Threats to the forest could be categorized into two types: i) illegal felling and hunting and ii) oil exploration. Recent settlers in the fringe area and tribal from the adjacent Arunachal Pradesh practice hunting and also tree felling, which is responsible for the removal of primary forest in small patches.

Garampani Wildlife Sanctuary and Nambor Doigurung Wildlife Sanctuary suffer from high extent of human disturbances, such as illegal felling, encroachment, poisoning of the bodies (for fishing). Much of the area had been encroached upon. Some local ethnic populations collect wild vegetable and fish for a livelihood.

The major threat to Rani RF and Kolaghat RF is large-scale tree felling and habitat destruction. Overcollection of forest produce (including material for making brooms, vegetable, etc) have also resulted in habitat alteration. Cattle grazing and hunting were also recorded during the study period. Collection of boulders from the stream-bed have greatly impacted the survival of stream-dwelling amphibians, specifically the larval stages.

Son Beel and Deeparbeel areas are seriously affected by siltation. Local people settled around the beels expanded their agriculture to the higher grounds. Further collection of aquatic vegetation and also fishing are other major occupation of the local people. Due to population increase, these two natural ecosystems are over-exploited and have shrunk to a large extent.

Pabitora Wildlife Sanctuary is also under heavy anthropogenic pressure, due to human settlement around this isolated grassland. Human influence in terms of regular collection of hay and cattle grazing can be observed. Further, flooding and heavy siltation impact amphibian populations.

The fringe areas of Innerline Forest are severely damaged, and are more or less of the open type. Felling of tree is the primary threat to the forest, besides large-scale bamboo collection. People of nearby areas also resort to dry wood collection here.

All Reserve Forests of Karimaganj are home to cosmopolitan populations, mainly belonging to Bengali (Muslims and Hindus), Khasis and Manipuris in addition to Tripuris, Chakmas and Tea tribes. Singla, which houses 16 forest villages and a Tongia (Revenue) village, supports a population of 30,000 and Tilbhum, which has only patches of secondary forests, become depleted due to encroachment for settling and agriculture. Except firewood collection in some areas of Singla, no forest produce was found to be collected in either of the areas. Duhalia (houses a forest village with a population of 5,000–6,000), faces two major threats- encroachment and tree felling, besides unrestricted grazing which prevent growth of secondary forest in cleared areas. Reserve Forests such as Badsahitila (houses a Tongia village, with a population ca. 2,000), Patharia (houses a forest village, a Tongia village; population 5,000) and North Cachar (large number of neo settlers) are also burdened with similar problems. The Longai RF (houses 24 forest villages and five Tongia (revenue) villages with a population of nearly 20,000) represents a condition of high human pressure and its primary forest has already been removed. This area presently has teak plantation and a growth of secondary forests in patches, along with bamboo grooves. All families here have agriculture as the primary source of livelihood. The low-lying areas of the reserves had been altered and a single cropping paddy cultivation is performed; residential houses and betel leaf (*Piper betle*) cultivation is practiced in the foothills. People of the area also engage in bamboo collection and fishing, as a secondary occupation. Cattle ranching and dry wood collection are also common in the area. Further, the stream has been diverted to the agriculture fields and also used for drinking. Though no sign of tree felling was observed, the landscape appeared disturbed to a great extent, but still supporting a varied amphibian fauna. Some of the threats to the forests of the area were:

Human population of the area has nearly doubled in the last two decades, and this poses as threat of encroachment. Further, tree felling has reduced the forest cover

In the betel cultivation, the undergrowth was totally removed, which destroyed microhabitats and prey-base of ground-dwelling amphibians.

Rampant bamboo collection for supply to consuming centres, especially paper mill, may eliminate the bamboo cover.

Teak plantation result in drying-up of forest floor, effecting undergrowth and thereby depleting amphibian m icrohabitats.

Tropical deforestation clears approximately ten percent of the original area per decade (Whitmore, 1997) and already half of the tropical and subtropical forests have been lost in the past 50 years (Myers, 1994). This causes a large and predictable loss of species (Pimm et al., 1995) and the postulated range of animal species extinction is 13–42% in south-east Asia over the next century, as a result of massive habitat loss (Brooks et al., 2003). The available data on forest cover in Assam also show the same trend, which poses a danger to the survival of many species. Despite intense searches, the caecilian, *Gegeneophis fulleri* could not be traced in the type locality and its surrounding habitats, and our study suggests the extinction of this species.

The present study noted that except for anthropophilous species, all amphibians, including the rare and endemic species, are forest dwellers. Further, all areas investigated are surrounded by altered habitats due to human settlement and/or agriculture. Most forests visited were disturbed. Although the boundaries of the protected areas, including the reserved forests, are documented, due to absence of any physical demarcation, most of the reserve forest areas were subjected to encroachment. All these situations yield adverse consequences of edge effects, leading to problem for their herpetofaunas (Summer et al., 1999).

Alcala et al. (2004) opined that amphibians were probably more prone to local extinction than birds and mammals because amphibians were more directly depend on critical factors in both land and freshwater environments. This is in contrast to Brooks et al. (2003), who suggested that the amphibians required less habitat space. During the present investigation in most of the Reserve Forest areas and also in some protected areas, a drastic reduction in natural habitat have been observed, presumably with severe decline in amphibian species. In the present study, it was observed that the disturbed areas are occupied by non-endemic and relatively common species. This finding is in conformity with Erdelen (1988) and Wijesinghe and Dayawansa (2002). Fox et al. (1998) opined that clearing of forest by logging and also for cultivation have extremely harmful effect on the core forest herpetofauna, and also invite invasion by non-endemics. Since endemic and rare species tend to be inferior competitors, they potentially face displacement in the presence of non-endemic invasive species. The removal of large trees reduces canopy cover and logging reduces humus and leaf litter along with moisture content of the air, thus making local environments inhospitable for niche specialists. Moreover, till the verdict of the Supreme Court of India, most of the reserve forest areas, including Dihing Patkai and Nambor Doigurung Wildlife Sanctuary are under extreme pressure of logging and that have created open spaces; consequently, moist deciduous or evergreen patches of forests have been tranformed into grasslands. A number of endemic and rare forest species, that are considered habitat specialists, have consequently disappeared from these patches in recent years.

Acknowledgements

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Seasonal variations in population densities of three lizard species along the Coromandel Coast, India

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(with five text-figures)

ABSTRACT.– Seasonal variations in population densities of different size classes of three lizard species - *Sitana ponticeriana*, *Calotes versicolor* and *Eutropis bibronii* in relation to that of abiotic environmental factors across scrubland, salai and sand dunes, respectively on the Coromandel coast near Chennai (India) were monitored. Regression analyses showed seasonal variations of adult population densities of *S. ponticeriana* significant positive relationship with mean maximum temperature and its hatchling population densities showed similar positive relationship with temporal variations in rainfall. Similarly, the adult population densities of *C. versicolor* showed significant positive relations with mean maximum and minimum temperatures. Its hatchling population densities and that of *E. bibronii* showed high significant negative relationships with seasonal variations in mean maximum and minimum temperatures. Multiple regression analyses reveal that seasonal variation in mean maximum and minimum temperatures show significant combined effects on adult and hatchling population densities of *C. versicolor* and on hatchling population densities of *E. bibronii*.

KEY WORDS.– Lizard seasonality, abiotic factors, maximum and minimum temperatures, monsoon, land use.

Introduction

Variation in life history attributes such as survival rates, population densities or individual growth rates may result from temporal fluctuations in environmental variables, such as temperature and moisture resulting from seasonality in rainfall and food availability, (Adolph and Porter, 1983; Dunham, 1981; Fleming and Hooker, 1975). The general distribution and biology of Indian reptiles is well documented (Daniel, 2002; Das, 2002; Tikader and Sharma, 1992; Murthy, 1990). It is believed that they are sparsely distributed and some species are endangered though in reality they are abundant in a given area. Though there are some studies on lizard assemblages in India, studies on the population ecology and behavior of Indian lizards are not many (Subba Rao and Rajabai, 1972; Shanbhag et al., 2003). Lizards are poikilothermic and

adapt behaviorally with well-developed thermal regulation mechanism, to the temporal changes in abiotic environmental factors particularly maximum and minimum temperatures, which are probably influenced by other abiotic factors, such as rainfall and relative humidity. There are distinct temporal variations in these abiotic environmental factors in the tropics. Seasonality in population dynamics of different age groups of various species of lizards is a subject that has hardly been looked into though it is well known that monsoon rains bring about a considerable change in the primary producers and consumers that in turn provide food and influence lizard populations. Monitoring of lizard populations in the wild during specific periods of time, based on their activity pattern and breeding season have been conducted by some workers (e.g., Zuiderwijk et al., 1998). Inger et al. (1987) con-

ducted a study on a herpetological assemblage in a small area of tropical evergreen forest in south India, which indicated that geographic isolation may be an important contributing factor to the diversity of the south Indian herpetofauna. Brown (1992) carried out a similar study on microhabitat relations of lizards and snakes in the Vadanemmeli area of southern India, by clustering species in 'microhabitat niche space', which indicated the presence of spatial guilds in their habitats.

Sitana ponticeriana Cuvier is a ground dwelling agamid lizard, diurnal in nature, commonly found in open sandy scrub jungles of India and Sri Lanka. It is distinguished from other agamids by the presence of four toes versus five. Sexual dimorphism, with males possessing a throat fan that turns bright blue during the breeding season is observed (Daniel, 2002; Das, 2002). *Calotes versicolor* Daudin, the common garden lizard, is widely distributed in India. There are few studies on the ecology of this lizard (Tiwari and Aurofilio, 1990; Sundaresan and Daniels, 1994). *Eutropis bibronii* Gray, a small subfossorial skink (Family Scincidae) is found in the coastal sand dunes in Tamil Nadu and little is known about its biology (Daniel, 2002; Das, 2002). Little published information is available on the seasonal variations in population densities of different species of Indian lizards in relation to the temporal changes in abiotic environmental factors. The present paper attempts to describe the seasonal variations in population densities of different size classes - hatchlings, juveniles and adults of three species of lizards in relation to temporal changes in abiotic factors, such as maximum and minimum temperatures, rainfall, soil surface temperature and relative humidity in three different habitats in the Coramandel coast, south of Chennai (India).

Materials and Methods

Study area.– The present study to monitor seasonal variations in population densities of three species of lizards was carried out in isolated pockets in three different habitats – salai, scrubland and sand dune, at Vadanemmeli (12°44'N, 80°14'E) (Fig 1a), ca. 42 km south of Chennai city, on the Coramandel coast in Tamil Nadu, southern India, with Salai habitats dominated by the Asian palmyra palm (*Borassus flabilifer*)

that harbored mainly common garden lizards (*C. versicolor*); scrubland habitat dominated by the dwarf bush (*Canthiam coromendelicum*), a native plant commonly found on the Coromandel coast and patches of grass inhabited by the fan throated lizard (*S. ponticeriana*) and sand dune habitat on the coast with *Spinifex littoreus* provided microhabitats for the highly habitat specific sand skink (*E. bibronii*).

Field sampling of lizard populations.– Population densities of lizards were sampled using the visual encounter survey method, that involved searching for lizards in each of the habitats (Campbell and Christman, 1982), and recording all animals visible on the surface (Corn and Bury, 1990). Three rectangular plots of 150 by 250 m were marked in each habitat; 15 quadrats of 50 x 50 m size were marked with wooden stakes in each of the rectangular plots of each habitat – Salai, scrubland and sand dune and were assigned a code. All lizards sighted in a quadrat were noted; their abundance was estimated as number of individuals per unit area (hectare). Though preliminary observations on the lizard populations were made from February 2006, intensive monitoring of the populations was carried out from April 2007. Data were recorded on time of sighting, grid number, soil surface (ground) temperature, relative humidity, species of lizard, sex, size class (i.e., adult, juvenile or hatchling), microhabitat - based on vegetation and distance from ground, behaviour - basking, resting or moving. Data were collected randomly in mornings and evenings with an average of two times (replicates) per month in each of the quadrats. The maximum and minimum temperature and the monthly total rainfall data were collected from the nearest meteorological station in Chennai. Soil surface temperature was measured using a digital laser thermometer (Raytek, USA – Model RAYST 3LXU), sensitive to the nearest 0.1°C. The relative humidity (%) was measured with a common thermohygrometer.

Statistical analysis.– MS Excel 2003 software was used for simple statistical analysis – the mean, standard deviation, standard error, and coefficient of correlation of the data. The same software was used to draw graphs on population density and also for regression analysis between four variables - hatchlings, juveniles, adults and total number of each species of lizards, and abi-
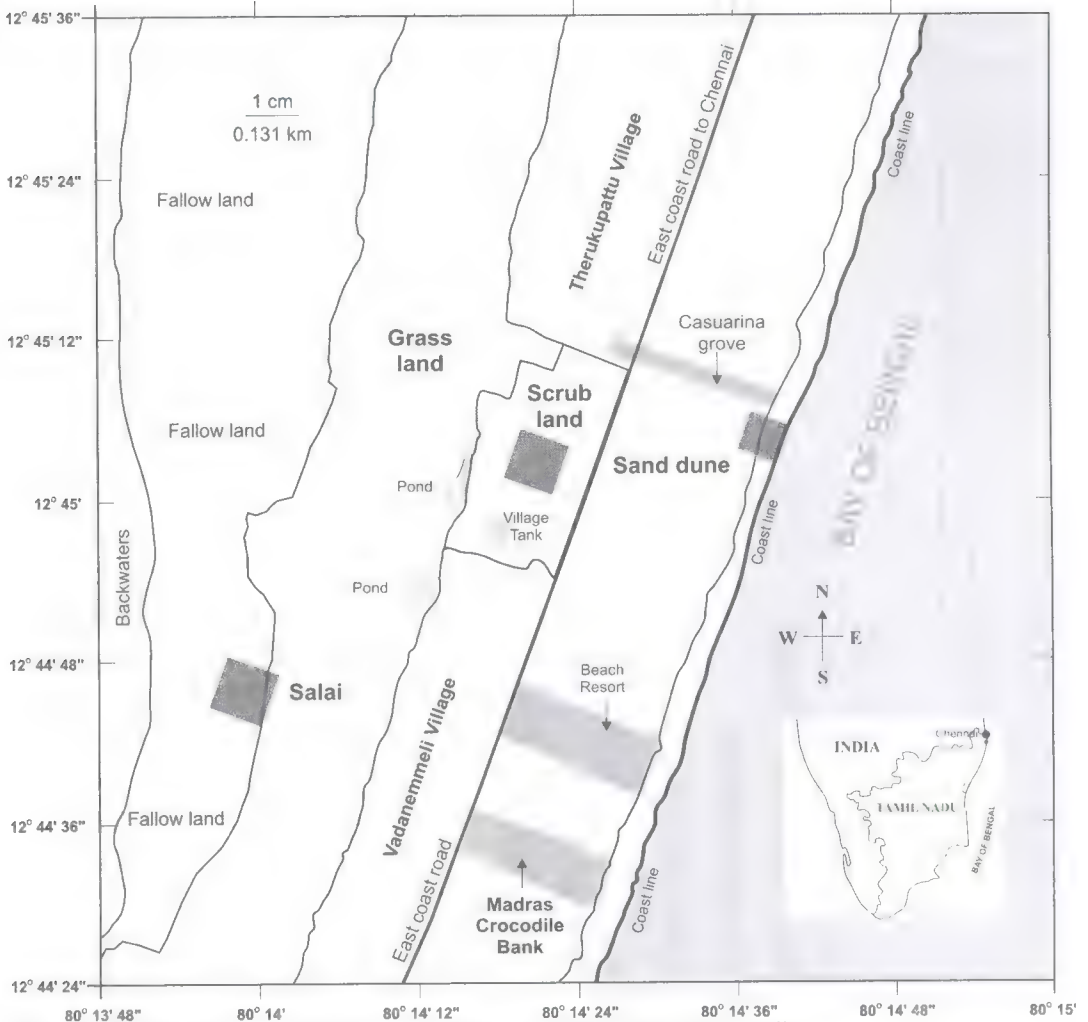
Figure 1. (a) Map showing study site in the Coromandel Coast, south-eastern India.

otic factors, such as monthly rainfall, soil surface temperature, maximum and minimum temperature, and relative humidity .

Results
Abiotic environmental factors.– The temperature in the study area was seasonally variable, with a monthly mean maximum temperature reaching a peak in May (39.2°C), and a monthly mean minimum reaching a low in January (21.7°C) (Fig. 1b). The rainfall at this location was bimodally distributed, with ca. 40% of rain falling during the South-west Monsoon, extending from July to mid-September and the remaining 60% of rain falling during the North-east Monsoon, spreading over September to December (Fig. 1b). The relative humidity of the habitats

varied from a minimum of 33.6% to a maximum of 72.8% in scrubland, from 59°C to a maximum of 73.75% in the Salai, and 58.25 to 74.25% in sand dunes (Fig. 2). Soil surface temperatures at the three habitats varied from 34.4 to 46.23°C in scrubland, 27.5 to 54.5°C in the Salai, and 33.5 to 45.3°C in sand dunes across different seasons (Fig. 2).

Lizard diversity.– The South-west and North-east Monsoons provided ideal conditions of temperature and main food (ground dwelling arthropods including insects) to the lizards and played a major role in the reproductive ecology and biology of different species of lizards (*Sitana ponticeriana, Calotes versicolor, Eutropis bibronii, E. carinata, Lygosoma punctata, Hemidactylus leschenaultii, Chamaeleo zeylan-*
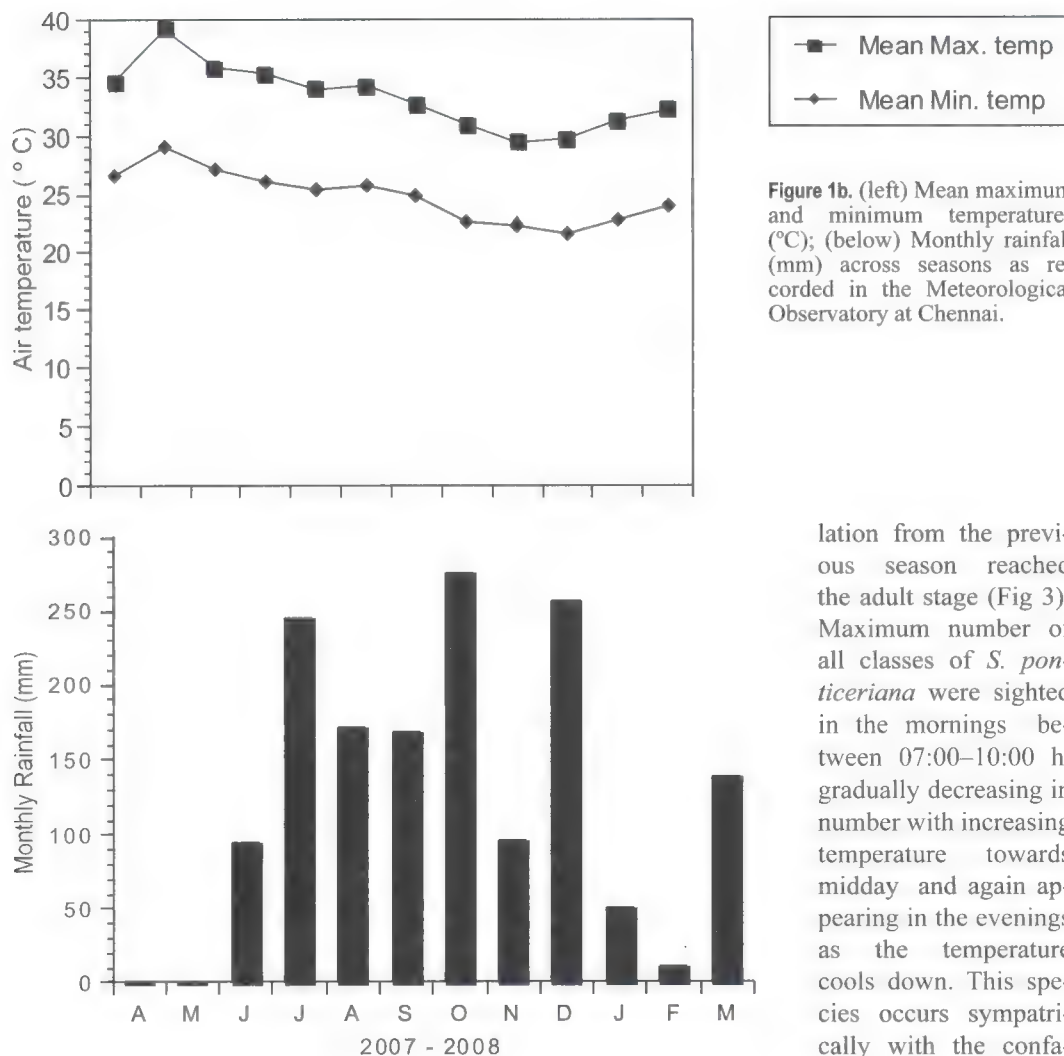
Figure 1b. (left) Mean maximum and minimum temperatures (°C); (below) Monthly rainfall (mm) across seasons as recorded in the Meteorological Observatory at Chennai.

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lation from the previous season reached the adult stage (Fig 3). Maximum number of all classes of *S. ponticeriana* were sighted in the mornings between 07:00–10:00 h, gradually decreasing in number with increasing temperature towards midday and again appearing in the evenings as the temperature cools down. This species occurs sympatrically with the confamilial *C. versicolor*

icus and *Varanus bengalensis*) recorded in study area of which the former three were dominant in their respective habitats.

Sitana ponticeriana.– Its adult snout to vent length (SVL) ranged from 45 to 50 mm, that of juveniles from 28 to 45 mm and hatchlings < 28 mm. Hatchlings and adults were found closely associated with microhabitats provided by dwarf bushes (*C. coramendelicum*) in the sandy scrubland habitats. Seasonal variation in population densities of *S. ponticeriana* indicated higher densities of its hatchlings (176.4 ± 23.6 per hectare) during the South-west and 170.9 to 256.3 mm during the North-east Monsoons, extending from July to December, some of which became juveniles (124.39 ± 42 per hectare), and a small number of the original hatchling popu-

(Fig 3). A higher total density of *S. ponticeriana* ranging from 146.2 to 192.5 per hectare was recorded during January to March. Smaller numbers of *S. ponticeriana* were also found in the sand dune habitat where hatchlings were seen as late as March (Fig. 5b).

Calotes versicolor.– This arboreal agamid is commonly found basking on the trunks of palm trees in the morning hours. Its adult SVL ranged from 90 to 150 mm, juveniles 60 to 90 mm and hatchlings < 60 mm. Hatchlings are brightly coloured. Males start developing red coloration in the gular region during breeding period. Adults are found breeding and involved in marking territories, courtship display, copulating and egg laying during the South-west Monsoonal months , probably because of the ideal conditions of am-

bient (i.e., maximum and minimum) temperatures created due to rainfall and relative humidity. A maximum density of *C. versicolor* (51.2–68.2 per hectare) was recorded during winter (January) and spring (March). Seasonal variations in its population density revealed that the hatchling population density was higher mainly during the months of October to February. It was found that the adult population (11.8 ± 1.2 per hectare) reproduced hatchlings of 19.6 ± 5.8 per hectare, which were recruited into the adult population before the following breeding season, indicating an annual cycle (Fig. 4).

Eutropis bibronii.– A subfossorial skink, with adults ranging from 35 to 42 mm SVL, juveniles 20 to 35 mm SVL and hatchlings < 20 mm SVL. Sexual dimorphism was observed with males having a pattern of red coloration on the dorsal-lateral side of body. A maximum density of *E. bibronii* (59.2 ± 26.7 per hectare) was recorded in the winter month of January and the hatchling population also reached its peak abundance (50.1 ± 15.4 per hectare) during this period (Fig. 5a).

Relationship between abiotic variables and lizard population densities.- Linear regression analyses between seasonal variation in population densities of different size classes of the three lizard species in relation to temporal variation in abiotic factors resulted in a statistically significant relationships for the lizard populations and the mean maximum and minimum temperatures and rainfall. A highly positive significant linear relationship was found between seasonal variation in adult population densities of *S. ponticeriana* and ambient mean maximum temperature indicating the influence of the variation in temperature on population densities
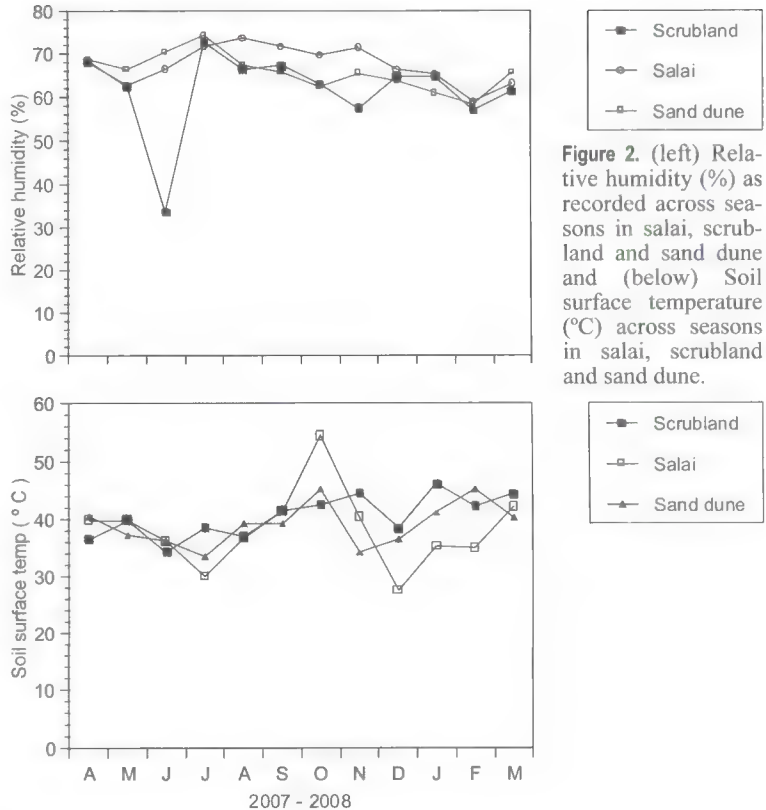
Figure 2. (left) Relative humidity (%) as recorded across seasons in salai, scrubland and sand dune and (below) Soil surface temperature (°C) across seasons in salai, scrubland and sand dune.

up to 80%, while the hatchling population of *S. ponticeriana* showed a positive significant relationship with rainfall indicating the influence of rainfall on the variation in hatchling population up to 31% (Table 1). There was also a linear significant positive relation between adult population densities of *C. versicolor* and the temporal variation in both mean maximum temperature and minimum temperatures indicating influence of these temperatures on adult populations up to ca. 45%. The hatchling population densities of *C. versicolor* and that of *E. bibronii* showed significant negative relationship with mean maximum temperature and minimum temperature, indicating the influence of temperatures on *C. versicolor* hatchling populations up to about 46 to 54%, and that of *E. bibronii* up to ca. 68% (Table 1).

Multiple regression analyses show the combined effect of maximum and minimum temperatures on seasonal variation in population densities. Adults of *C. versicolor* and hatchlings *E. bibronii* showed positive significant effect of temperatures on the former and highly signifi-

Sitana ponticeriana across seasons in scrubland
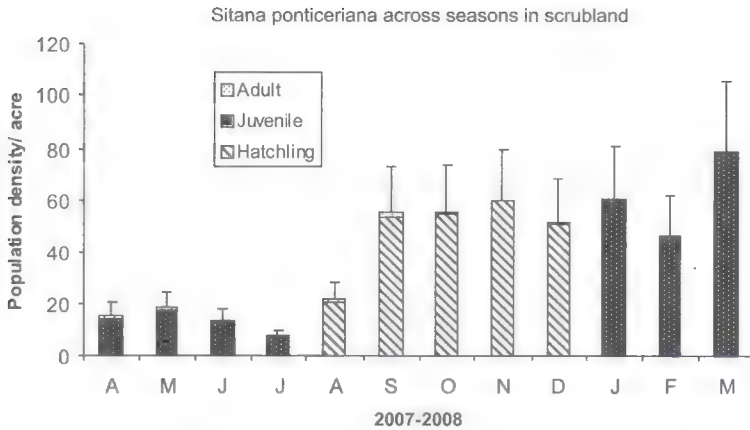
Figure 3. Population densities of (above) *Sitana ponticeriana* and (below) *Calotes versicolor* across different seasons in the scrubland.

Calotes versicolor across seasons in scrubland

Calotes versicolor across seasons in salai
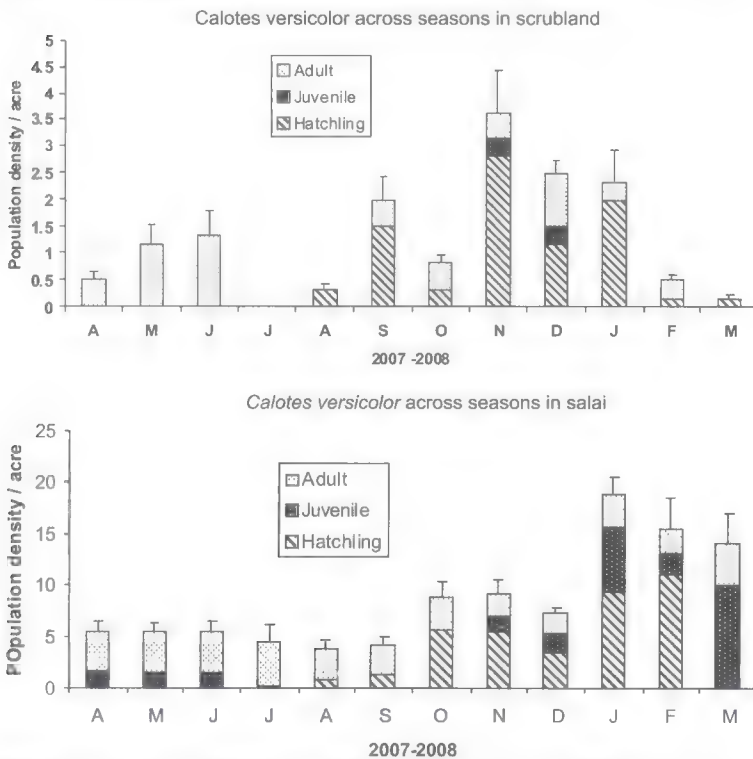
Figure 4. Population densities of *Calotes versicolor* across seasons in salai

variation in population densities of lizards during the study period.

Discussion

In the tropics seasonal changes in temperature tend to be minimal, and rainy seasons tend to alternate with sometimes with one, or two dry seasons each year (Wolda, 1988). Soil arthropods, including insects and their larvae, that form the major food items of lizards were recorded in abundance and active on the soil surface during the rainy season (Reddy and Venkataih, 1990). Pal (2006) reported that arthropods constitute the major food of hatchlings and adults of lizards. The high significant positive relations between the temporal variations in maximum and minimum temperatures, and that of rainfall and *C. versicolor* adult populations densities indicated the importance of these abiotic variables in the population dynamics of the lizard. Similarly, the significant negative relation

cant negative effect on the hatchling population of *E. bibronii*, indicating the positive combined influence of both the temperatures on the adult *C. versicolor* populations up to ca. 46 per cent, and negative influence on the hatchling populations of *C. versicolor* up to 58% and that on the hatchlings of *E. bibronii* up to 68% (Table 2). However, temporal changes in relative humidity and soil temperatures of the habitats did not show any significant relation with seasonal

found particularly between the temperatures and hatchling population of *C. versicolor* and that of *E. bibronii* indicate the unfavourable influence of increased temperatures on the developing stages of the lizards.

Demographic study on *S. ponticeriana* in a cotton field in Dharwad (Karnataka, India) indicated a density of 45 ± 2.19 per 1.9 hectare (Shanbhag et al., 2003). These densities are relatively lower when compared to the den-

sity (169.4 ± 83.6 per hectare) recorded during the present study at Vadanemmeli. This could be attributable to variation in reproductive season reported to be between April and May at Dharwad with semi-arid dry conditions, where the South-west Monsoon showed more influence than North-east Monsoon. At Vadanemmeli, the breeding season of *S. ponticeriana* occur between September and December, when the North-east Monsoon was more active. It indicated that there is a variation in the breeding season of the agamid lizards under different climatic regions, which may be attributable to the variation and influence of the monsoon on other
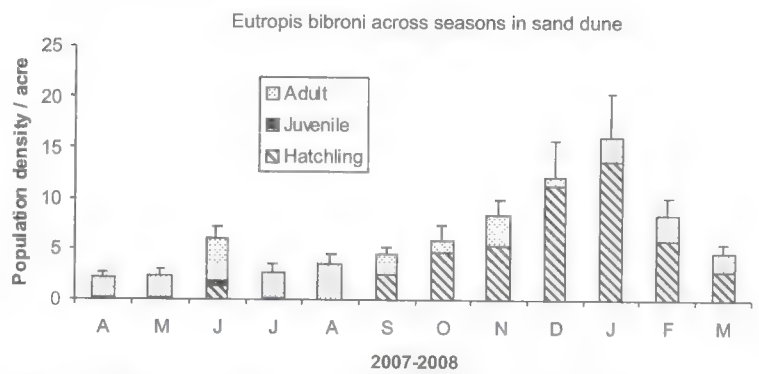
Figure 5. Population densities of (a.) *Eutropis bibronii* and (b) *Sitana ponticeriana* across seasons in sand dune.
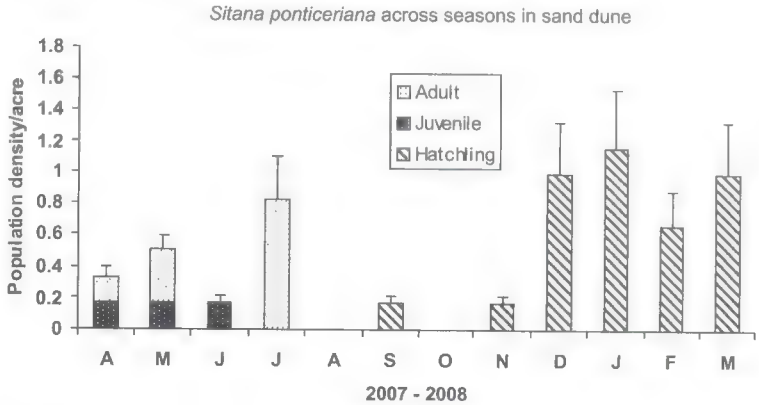
components of environment and ecosystem. However, maximum number of lizards was

Table 1. Regression analyses between seasonal variations in mean maximum and minimum temperatures and rainfall and that of adult and hatchling population densities of three lizard species (* P < 0.05; **P < 0.01)

Habitats	Lizard species	Age groups	Abiotic factor	'R2'Value	Regression Equation
Scrubland	*S. ponticeriana*	Adult	Mean Maximum Temp(° C)	0.8013281**	y = 0.67x - 19.60
		Hatchling	Rainfall (mm)	0.3171269*	y = 0.55x +4.99
Salai	*C. versicolor*	Adults	Mean Maximum Temp.(° C)	0.4588387*	y= 0.67x - 10.61
			Mean Minimum Temp(° C)	0.4410798*	y= 0.82x - 8.79
		Hatchlings	Mean Maximum Temp(° C)	0.464775*	y=-3.51x + 128.24
			Mean Minimum Temp(° C)	0.5426676**	y = - 4.75x + 129.76
Sand dune	*E. bibronii*	Hatchling	Mean Maximum Temp(° C)	0.6788727**	y = - 4.85x +176.09
			Mean Minimum Temp(° C)	0.6884453**	y = - 6.12x + 167.06

Table 2. Multiple regression analyses between seasonal variations in mean maximum and minimum temperatures and that of population densities of adult and hatchling populations of different lizard species (* P < 0.05; ** P < 0.01)

Habitats	Lizard species	Age groups	Abiotic factors	'R2'Value	Regression Equation
Salai	*C. versicolor*	Adults	Mean minimum and Maximum Temp.(° C)	0.4588498*	y= 0.69x1 - 0.02x2 - 10.63
		Hatchlings	Mean minimum and Maximum Temp.(° C)	0.5887606**	y = - 5.76x1 - 11.83 x2 + 14.44
Sand dune	E. bibronii	Hatchlings	Mean minimum and Maximum Temp.(° C)	0.690969**	y = - 1.54x1 - 4.23 x2 + 171.16

found basking in the morning hours under both the regions.

A density of 11.18 per hectare was reported in a population study on the agamid, *C. versicolor* in Vadanemmeli in the Madras Crocodile Bank (Sundaresan and Daniels, 1994). The Crocodile Bank is well planted vegetation with trees mainly Neem, *Azadirachta indica*. In concordance with these findings, a density of 11.84 per hectare was found during the present study in the palm tree habitat of Salai. Clumped distribution of lizards was reported in both the studies. Sluys (2000) reported that the population dynamics of *Tropidurus itambere* (Tropiduridae) in southeastern Brazil varied with rainfall. Its population density was 52.3 ± 7.1 individuals/hectare which oscillated throughout the sampling period with egg-laying occurring in rainy season (November-March) and recruitment occurred from January-April. Increase in estimated density resulted mainly from the greater number of juvenile lizards. These findings are similar to the present findings recorded at Vadanemmeli.

Though little information is available on the influence of abiotic environmental factors on population densities of *E. bibronii* in sand dune ecosystems, Subramanean and Reddy (2010) recently reported the influence of changed temperature profile of the sand dunes ecosystem due to casuarina (*Casuarina equisetifolia)* plantations on the basking activity of *E. bibronii.* Their populations were low because of reduced temperature due to increased shade created by the casuarinas plantations. Non-arable land such as scrubland, salai and sand dunes on the Coramandel coast are inhabited by many species of lizards, with three species being dominant. Mean maximum and mean minimum temperatures were found to influence the population densities of different size classes of the three lizard species - *S. ponticeriana, C. versicolor* and *E. bibronii*. Seasonal rainfall was found to play a key role in the ecology of these lizards with hatchlings appearing in higher densities during the monsoons, which increase in size to become adults in the following year. These habitats on the Coramandel coast are fast getting disturbed by various forms of land use and other anthropogenic activities, including tourism, which should be a cause for concern in terms of protection of biodiversity, including lizard species.

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Catalogue of Indian herpetological specimens in the collection of the Government Museum Chennai, India

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ABSTRACT.– We list all available wet-preserved, entire, herpetological specimens and furnish their register history, accession number, collection locality, source and any jar label information. A total of 154 species, consisting of one salamander, six caecilians, 31 anurans, three testudines, 47 lizards and 66 snakes were observed. All specimens are non-types; eight need taxonomic clarification; 27 amphibian specimens could not be traced at present. Additional remarks on nomenclature, taxonomy and distribution are provided.

KEYWORDS.– Amphibians, reptiles, catalogue, history, Government Museum, Chennai.

Introduction

The Government Museum Chennai is one of the largest and oldest of the State Museums in India. It was started by Surgeon Edward Balfour in 1851, who was the first officer-in-charge (1851–1859). It began as a museum of practical geology, but its scope was soon extended to cover other fields such as archaeology, ethnology, prehistory, national art Gallery, numismatics, chemical conservation, children's section, geology, botany and zoology.

The Zoology Section is one of the largest, with 11 galleries consisting of fish, amphibian, reptile, bird, mammal, coral and invertebrate galleries. Although its scope is mainly limited to south Indian fauna, a few exotic species exhibits have been added to enhance the interest of visitors (Satyamurti, 1964). Some of the museum's herpetological specimens have been examined in the past (e.g., Theobald, 1868; Smith, 1943; Smith et al., 2008; Das and Singh, 2009). Besides the exhibited collection, a large reserve-collection of over a hundred specimens stored in jars and cabinets exists.

Most of the collections are from southern India. Specimens from many localities are represented, from the east coast (Kunavaram, East Godavari, Ennore, Porto Novo, Chidambaram, Ramnad, Krusadai Islands), west coast (Cochin,

Ernakulam, Kottayam), Eastern Ghats (Nallamalais, Tirupati, Horsleykonda, Chittoor, Udayagiri) and Western Ghats (Anaimalais, Pulneys, Kodaikanal, Shenbaganur, Parambikulam, Palghat, Chalakudy, Coorg, Ootacamund, Coonoor, Nilgiris, Naduvattam, Wayanad, Nilambur, Sirumalais, Netterikkal, Tirunelveli). Many specimens were obtained from in and around Madras (now Chennai) city, particularly from the Red Hills, Tambaram, Chengelpet, Kambakkam, including some from the museum compound. Dr. Frederick Henry Gravely and Professor Edward Barnes were the main collectors. M. A. Badsha of the Madras State Wildlife Office, G. W. Easton of Nilgiris, E. Madhavan of Ooty, Father Guthrie of Shenbaganur, Joshua of Christian College, H. Heechan, Duffy and F. Thomas of Madras, were notable among donors of reptile specimens, while G. S. Meyers of California, Karunakara Nair of Ernakulam and L. S. Ramaswamy of Intermediate College Mysore, donated/collected amphibian specimens. Major institutions in the city, such as the Madras Corporate Zoo, Madras Snake Park, Madras Christian College and Presidency College, have also either donated or exchanged specimens, thus enriching the collection.

Though Thurston (1888) and Satyamurti (1960; 1962; 1967) have dealt with this collec-

tion, extensive details pertaining to the specimens housed are available only for amphibians; for reptiles, anecdotal natural history accounts exist. Considering the changes in Indian amphibian taxonomy and nomenclature in the recent years (Frost et al., 2005; Bocxlaer et al., 2009), we present this catalogue, which covers both amphibians and reptiles . The register history and accession number details are available only from the year 1931, but since Thurston (1888) had written extensively about the collection's amphibian specimens, it is credible that there was an extensive collection of specimens from its early years. Therefore, many specimens remain unregistered. All the specimens housed in this collection are non-types.

Materials and Methods

The present catalogue includes wet-preserved, entire, herpetological specimens present in both the exhibit and the reserve collections and we furnish their register history, accession number and jar label details. Exotic species, eggs, tadpoles/ metamorphs, dry-preserved exhibits, skeletal preparations, dioramas, paintings, photographs and other such, maintained for exhibit and public education, awareness purposes are not dealt with here. Specimens of doubtful identity, present in the reserve-collection, were examined and our identifications are presented herein. Label-names of those specimens, which do not agree with current nomenclature, are mentioned. Institutional abbreviation follows Smith et al. (2008). Those on display in the exhibit gallery are marked with an asterisk (*). Specimens once reported in the collection by Thurston (1888), but are currently untraceable are listed at the end.

Catalogue of Specimens
Amphibia
Caudata

Salamandridae

Tylototriton verrucosus (Anderson, 1871)
    Material: MAD 11.1973* and 12.1973* both from Darjeeling.

Gymnophiona
Ichthyophiidae

Ichthyophis peninsularis Taylor, 1960
    Material: MAD 1.4.1946, labelled as "*Icthyophis monochrous*" from Kambakkam, Chengelpet hills; another unnumbered specimen from unknown locality.
    Remarks: *Ichthyophis monochrous* (part) Boulenger, 1882 (non Bleeker, 1858) is a partim description of *I. peninsularis* Taylor, 1960 (Bhatta, 1997; Daniel, 2002; Daniels, 2005; Dutta, 1997). Daniels (2005) listed Kambakkam, Eastern Ghats near Chennai in the distribution of *I. peninsularis*, supporting our specimen's provenance, which is at variance to data in Bhatta (1997), Daniel (2002) and Dutta (1997).

Ichthyophis subterrestris Taylor, 1960
    Material: MAD no number* from Kambakkam, Madras, determined by G. S. Meyers; MAD 6.10.1977 from Ootacamund, Nilgiris.
    Remarks: *I. subterrestris* has never been reported from Kambakkam (Bhatta, 1997; Daniel, 2002; Daniels, 2005; Dutta, 1997). Additionally, Daniels (2005) stated that this species is closely related to *I. peninsularis*, a species distributed in Kambakkam (Daniels, 2005).

Ichthyophis beddomei (Peters, 1879)
    Material: MAD no number, labelled as "*Ichthyophis glutinosus*" from Kutarai Pass, South Coorg.
    Remarks: Bhatta (1997), Daniel (2002), Daniels (2005) and Dutta (1997) remarked that Indian records of the Sri Lankan-endemic *I. glutinosus* are based on misidentifications of superficially similar looking *I. beddomii* and *I. tricolor.* Thurston (1888) mentioned "*Ichthyophis glutinosus*" from Wynaad, but at present, no *Ichthyophis* from Wynaad could be located in this collection.

Ichthyophis tricolor Annandale, 1909
    Material: MAD 15.10.1941*, labelled as "*Ichthyophis glutinosus*" from Kottayam, collected by L. S. Ramaswamy, Intermediate College, Mysore; more unnumbered specimens* from Kavalai, Kochi and another unnumbered specimen labelled as "*Ichthyophis glutinosus var. tricolor*" from an unknown locality.

Note: For remarks on *Ichthyophis glutinosus*, see accounts on *Ichthyophis beddomei*.

Uraeotyphlidae

Uraeotyphlus menoni Annandale, 1913

Material: MAD no number from Kondiatti, South Malabar; another unnumbered specimen from an unknown locality.

Uraeotyphlus narayani Seshachar, 1939

Material: MAD 15.10.194* from Kottayam , collected by L. S. Ramaswamy, Intermediate College, Mysore.

Anura
Bufonidae

Duttaphrynus scaber (Schneider, 1799)

Material: MAD no number* labelled as "*Bufo fergusoni*" from Udayagiri, Nellore district and another unnumbered specimen from Ernakulam, Cochin.

Remarks: *Bufo fergusoni* Boulenger (1892) is a junior subjective synonym of *Bufo scaber* Schneider, 1799 (not of Daudin, 1802) (Dubois and Ohler, 1999).

Duttaphrynus hololius (Günther, 1876)

Material: MAD no number*, labelled as "*Bufo hololius*" from Horsleykonda, Chittoor district, another unnumbered specimen from Nellore district.

Remarks: Satyamurti (1967) mentioned three specimens in Madras Museum, but at present, we could locate only two. Dutta (1997) doubted the species identity of Satyamurti (1967), as he did not specify having compared them with the holotype, but these specimens are *Duttaphrynus hololius*, an issue which will be addressed elsewhere (Chandramouli et al., in prep.).

Duttaphrynus melanostictus (Schneider, 1799)

Material: MAD no number, labelled as "*Bufo melanostictus*" from Kunavaram, East Godavari district; additional unnumbered specimens from Madras, Coimbatore and Horsleykonda.

Remarks: Thurston (1888) mentioned of specimens from Cochin, Ootacamund and Kotagiri, which we could not locate. Satyamurti (1967) reported "*Bufo microtympanum*" and "*Bufo parietalis*" from Madras, Horsleykonda, Cochin and Nagari of Chittoor district but these specimens actually are *Duttaphrynus melanostictus*.

Duttaphrynus microtympanum (Boulenger, 1882)

Material: MAD no number, labelled as "*Bufo microtympanum*" from Wynaad, Dhoni forest; more unnumbered specimens from Netterikal, Kalakkad forest, Tirunelveli hills.

Remarks: Thurston (1888) mentioned of specimen from Kodaikanal, Pulney hills ("7000 feet") which we could not locate. Satyamurti's (1967) records from Madras and Horsleykonda are based on misidentified *Duttaphrynus melanostictus* specimens. *Duttaphrynus microtympanum sensu stricto* is restricted only to the Western Ghats of India and is absent elsewhere in peninsular India and also Sri Lanka as demonstrated by Biju (2001); Dubois and Ohler (1999) and Manamendra-Arachchi and Pethiyagoda (1998).

Duttaphrynus parietalis (Boulenger, 1882)

Material: MAD no number, labelled as "*Bufo parietalis*" from Ootacamund.

Remarks: Satyamurti's (1967) records from Cochin and Nagari, Chittoor district are based on misidentified *Duttaphrynus melanostictus* specimens.

Microhylidae

Ramanella montana (Jerdon, 1854)

Material: MAD 4.3.1914, labelled as "*Kaloula obscura*" from Thomra, southern Coorg.

Remarks: Satyamurti (1967) referred this material as *Ramanella montana*. However, this species has a confusing nomenclatural history. Boulenger (1882) created a nominal species *Callula obscura* (non Günther, 1864) as a partim description, which was also followed by Sclater (1892), before Parker (1934) gave it the current combination *Ramanella montana* Parker, 1934, which has been unequivocally accepted (see Dutta, 1997).

Ramanella triangularis (Günther, 1875)

Material: MAD no number, labelled as "*Kaloula triangularis*" from Wynaad.

Remarks: Thurston (1888) mentioned a specimen from Ootacamund 7000 feet, which we could not locate.

Ramanella variegata (Stoliczka, 1872)
Material: MAD no number, from Madras.

Kaloula taprobanica Parker, 1934
Material: MAD no number ,labelled as "*Kaloula pulchra*" from Madras.

Microhyla rubra (Jerdon, 1853)
Material: MAD no number, from Madras , Red Hills, Udayagiri and Bangalore.
Remarks: Thurston (1888) mentioned of specimens from Nilgiris and Tinnevelly, which we could not locate.

Microhyla ornata Duméril and Bibron, 1841
Material: MAD no number, from Bangalore; another unnumbered specimen from Madras.

Uperodon systoma (Schneider, 1799)
Material: MAD no number, labelled as "*Ramanella systoma*" from Madras; another unnumbered specimen labelled as "*Cacopus systoma*" from the museum compound.
Remarks: Thurston (1888) mentioned of specimen from Nilgiris, which we could not locate.

Uperodon globulosum (Günther, 1875)
Material: MAD no number labelled as "*Cacopus globulosus*" from Russelkonda, Ganjam district

Rhacophoridae

Philautus signatus
Material: MAD 20.80.V.21, three specimens, labelled as "*Ixalus variabilis*" and collected by F. H. Gravely from "ca. 6700-8000 feet" in Ootacamund, Nilgiris.
Remarks: *Philautus variabilis* (Günther, 1859) is a Sri Lankan endemic, extinct species, known from the lectotype (Manamendra-Arachchi and Pethiyagoda, 2005). Indian records of *Philautus variabilis* were based on *Philautus anili* Biju and Bossuyt, 2006, *P. kani* Biju and Bossuyt, 2009, *P. signatus* (Boulenger, 1882) and *P. tinniens* (Jerdon, 1853) (see Biju and

Bossuyt, 2009). Thurston (1888) mentioned of specimens from Pycara and Conoor in Nilgiris, but we could not locate them.

Philautus wynaadensis (Jerdon, 1853)
Material: MAD 17– 26.V.23, labelled as "*Philautus leucorhinus*", and collected by E. Barnes, from "1500-4000 feet" in Dhoni, South Malabar, and MAD unnumbered, labelled as "*Philautus variabilis*" from Kavalai, Cochin in Kerala.
Note: For remarks on the name *Ixalus* (currently, *Philautus*) *variabilis,* see *Philautus signatus* account.
Remarks: *Philautus leucorhinus* (Lichtenstein, Weinland and Von Martens, 1856) is a Sri Lankan endemic extinct species, known from the lectotype (Manamendra-Arachchi and Pethiyagoda, 2005). Indian records of *P. leucorhinus* are based on *P. wynaadensis* (Jerdon, 1853), *P. amboli* Biju and Bossuyt, 2009 and *P. kani* Biju and Bossuyt, 2009 (Biju and Bossuyt, 2009).

Philautus sp. 1.
Material: MAD 1930, labelled as "*Philautus variabilis*" collected by F. H. Gravely from "ca. 6000-6800 feet" in Kodaikanal, Palni hills, during the months of July-September.
Note: For remarks on the name *Ixalus* (currently *Philautus*) *variabilis,* see *Philautus signatus* account.
Remarks: This specimen has smooth dorsum and unpatterned pupil and thus differes from the two, described, extant Rhacophorines, *Ghatixalus asterops* Biju, Roelants and Bossuyt, 2008 and *Philautus dubois* Biju and Bossuyt, 2006, that occur in the region (Biju et al., 2008 and Biju and Bossuyt, 2006; 2009).

Philautus sp. 2.
Material: MAD no number*, labelled as "*Ixalus variabilis*" from Shevaroy hills.
Note: For remarks on the name *Ixalus* (currently *Philautus*) *variabilis,* see *Philautus signatus* account.
Remarks: Apart from the reports of "*Philautus variabilis*" from Shevaroy hills, Kolli hills and Golconda, the only valid congener, reported from Eastern Ghats is *Philautus terebrans* Das and Chanda, 1998, which is known from its type locality and its vicinity (Daniels 2005; Das and

Chanda 1998; Dutta 1997). Therefore the *Philautus* population in Shevaroy hills is yet to be verified.

Polypedates maculatus (Gray, 1834)

Material: MAD no number, labelled as "*Rhacophorus maculatus*" from Trichur, Kochin and Kambakkam, Madras and Udayagri.

Remarks: Thurston (1888) metioned of specimen from Shevaroys, "5000 feet", which we could not find.

Rhacophorus malabaricus Jerdon, 1870

Material: MAD 20.11.1933* and MAD no number, both from Ernakulam, Cochin state, received from K. Karunakara Nair.

Petropedetidae

Indirana leptodactylus (Boulenger, 1882)

Material: MAD no number* from Coorg; more unnumbered specimens, labelled as "*Rana leptodactyla*" from Trichur, Kavalai and Perambikulam.

Ranidae

Clinotarsus curtipes (Jerdon, 1853)

Material: MAD no number*, labelled as "*Rana curtipes*" from Bangalore.

Remarks: Thurston (1888) mentioned a specimen from Wynaad, which we could not locate. This species has not been reported from Bangalore (Daniel, 2002; Daniels, 2005; Dutta, 1997).

Hydrophylax malabarica (Tschudi, 1838)

Material: MAD no number, labelled as "*Rana malabarica*" from Cochin; more unnumbered specimens from Netterikkal , Kalakkad forest, Tirunelveli hills.

Dicroglossidae

Fejervarya keralensis (Dubois, 1980)

Material: MAD no number, labelled as "*Rana verrucosa*" from Parambikulam; more unnumbered specimens from Chalakudy, Ernakulam, Cochin and Dhoni, southern Malabar.

Sphaerotheca breviceps (Schneider, 1799)

Material: MAD no number, labelled as "*Rana breviceps*" from Trichur; another unnumbered specimen from Red Hills, Madras.

Remarks: Thurston (1888) mentioned a specimen from Tinnevelly (= Tirunelveli), which we could not locate.

Fejervarya limnocharis species-complex *sensu* Dutta (1997)

Material: MAD no number labelled as "*Rana limnocharis*" from Trichur; additional unnumbered specimens from Cochin, Chalakudy, Ootacamund, Yercaud, Madras and Nallamalai.

Hoplobatrachus tigerinus (Daudin, 1803)

Material: MAD no number, labelled as "*Rana tigerina*" from Trichur, Travancore; another unnumbered specimen from Ernakulam, Cochin.

Remarks: Thurston (1888) mentioned specimens from Madras and Nilgiris, but we could not locate them. Satyamurti's (1967) record of *Rana tigerina* from Madras and Horsleykonda is based on misidentified specimens of *Hoplobatrachus crassus*.

Hoplobtarachus crassus (Jerdon, 1853)

Material: MAD no number, labelled as "*Rana tigerina*" from Madras and Udayagiri.

Remarks: Satyamurti (1967) mentioned these to be *Rana tigerina*, but these specimens are *Hoplobatrachus crassus*.

Euphlyctis cyanophlyctis (Schneider, 1799)

Material: MAD no number, labelled as "*Rana cyanophlyctis*" from Dhoni, South Malabar, Madras, Tittimatti and Thomra, southern Coorg, Bangalore, Horsleykonda, Chittoor district, Atinakur, Kurnool district, Ramanathapuram, Chalakudy, Netterikkal, Kalakkad forest, Tiruneveli and Ernakulam.

Remarks: Thurston (1888) mentioned specimens from Madras, but we could not locate them.

Nyctibatrachidae

Nyctibatrachus major (Boulenger, 1882)

Material: MAD no number, labelled as "*Nyctibatrachus* sp." from Dhoni, South Malabar; another unnumbered specimen from Ka-

valai, Kerala and Netterikkal, Kalakkad forest, Tirunelveli hills.

Micrixalidae

Micrixalus phyllophilus (Jerdon, 1853)

Material: MAD no number, labelled as "*Micrixalus opisthorhodus*" from Kotagiri, Nilgiris; another unnumbered specimen from Coonoor, Nilgiris.

Micrixalus silvaticus (Boulenger, 1882)

Material: MAD no number from Ootacamund; another unnumbered specimen from Coonoor, Nilgiris.

Reptilia
Testudines
Bataguridae

Melanochelys trijuga trijuga (Schweigger, 1814)

Material: MAD 10.1.1956/1, labelled as "*Geoemyda trijuga*" from Madras.

Vijayachelys silvatica (Henderson, 1912)

Material: MAD no number, labelled as "*Heosemys silvatica*" from Chalakudy, Kerala.

Remarks: Moll et al. (1984) wrote "the first known specimen of *Heosemys silvatica*, an adult male was collected by Kadar tribals and presented to a collecting party headed by J. R. Henderson, Superintendent of Madras Govt. Museum". Henderson, who originally described this species, was associated with this Museum, and is apparently the collector of this specimen (Moll et al., 1984:112). Moll et al. (1984) also stated that the type is now at Zoological Survey of India, Kolkata, and bears the number ZSI 17115. Therefore, it is unclear whether this specimen forms part of the type series.

Trionychidae

Lissemys punctata punctata (Bonnaterre, 1789)

Material: MAD no number, labelled as "*Emyda granosa* var. *vittata*" from Madras.

Sauria
Gekkonidae

Geckoella collegalensis (Beddome, 1870)

Material: MAD no number*, labelled as "*Gymnodactylus nebulosus*" from Collegal hills; MAD 11.16.IX.1928, collected by E. Barnes from "3000-4100 feet" in Horsleykonda, Chittoor district.

Cnemaspis indica (Gray, 1846)

Material: MAD no number* from Nilgiris; MAD 24.IX.3.X.25, labelled as "*Cnemaspis beddomei*" collected by E. Barnes from The Kundas, Nilgiris.

Cnemaspis wynadensis (Beddome, 1870)

Material: MAD no number*, labelled as "*Gonatodes wynadensis*" from Thomra, South Coorg, and more unnumbered specimens from Wynaad, Trichur state and Perambikulam.

Cnemaspis ornata (Beddome, 1870)

Material: MAD no number, labelled as "*Gonatodes ornatus*" from Travancore and Tiruneveli hills.

Cnemaspis beddomei (Theobald, 1876)

Material: MAD 26.V-6.VI.27, collected by E. Barnes from "3000-4000 feet" in Netterikkal, Kalakkad forest, Tirunelveli district.

Cnemaspis mysoriensis (Jerdon, 1853)

Material: MAD no number*, and two additional unnumbered specimens, all from Mysore.

Remarks: Giri et al. (2009) recently stabilized the name of this taxon by a neotype designation and redescription.

Cnemaspis gracilis (Beddome, 1870)

Material: MAD no number*, from Sirumalais.

Cnemaspis littoralis (Jerdon, 1853) *incertae sedis* (Manamendra-Arachchi et al., 2007)

Material: MAD no number, labelled as "*Cnemaspis littoralis*" from Nellakotta, Madura district.

Remarks: The specimen is in a poor state of preservation, and could not be examined.

Taxonomic notes: Smith's (1935) view of *Gymnodactylus* (currently, *Cnemaspis*) *planipes* Beddome, 1870, being a subjective synonym of *Gymnodactylus* (currently, *Cnemaspis*) *littoralis* Jerdon, 1853 may be incorrect; its status remain unclear as the types of these nominal taxa are now lost (Manamendra-Arachchi et al., 2007).

Cnemaspis sp.

Material: MAD no number, and one additional unnumbered specimen, both labelled as "*Cnemaspis kandiana*" from unknown locality and from Chalakudy, Cochin state, respectively.

Remarks: The specimens are in poor state of preservation and could not be examined.

Taxonomic notes: *Cnemaspis kandiana* (Keelart, 1852) and its subspecies *Gonatodes kandianus tropidogaster* Boulenger, 1885 [currently, *Cnemaspis troidogaster* (Boulenger, 1885)] are endemic to Sri Lanka (Manamendra-Arachchi et al., 2007). Indian records of *C. kandiana* are based on *C. indraneildasii* Bauer, 2002 (from North Kanara), *C. monticola* Manamendra-Arachchi, Bhatuwita and Pethiyagoda, 2007 (from Wynaad), *C. australis* Manamendra-Arachchi, Bhatuwita and Pethiyagoda, 2007 (from Tirunelveli) and *C. nilagirica* Manamendra-Arachchi, Bhatuwita and Pethiyagoda, 2007 (from Nilgiris) (Bauer, 2002; Manamendra-Arachchi et al., 2007) .

Calodactylodes aureus (Beddome, 1870)

Material: MAD no number*, and two additional unnumbered specimens, labelled as "*Calodactylus aureus*" from Cudappah hills.

Hemidactylus anamallensis (Günther, 1875)

Material: MAD no number*, labelled as "*Dravidogecko anamallensis*" from Pulneys; another unnumbered disintegrated specimen labelled as "*Hoplodactylus anamallensis*" from Palni hills.

Hemidactylus maculatus Duméril and Bibron, 1836

Material: MAD no number*, from Coimbatore; another unnumbered specimen from Collegal.

Remarks: The specimen from Coimbatore is in poor state of preservation.

Hemidactylus triedrus (Daudin, 1802)

Material: MAD no number*, from Nilgiris; MAD 1924 from Madras; Udayagiri; Nallamalai, Kurnool district; Kanigeri, Nellore district; Horsleykonda, Chittoor district.

Hemidactylus subtriedrus Jerdon, 1853

Material: MAD no number*, from Cadappah district

Remarks: Smith (1935) considered the specific distinction of this taxon to be doubtful. Subsequently, Javed et al. (2009) reported two more *H. subtriedrus* specimens from Araku Valley and reconfirmed its specific distinction. Past records of distribution of this taxon have been from eastern peninsular India in Tamil Nadu, Andhra Pradesh and Orissa states, with doubtful records from Kanpur and Aurangabad (Javed et al., 2009) is consistent with our specimen from Cadappah.

Hemidactylus brookii Gray, 1845 *sensu* Smith (1935)

Material: MAD no number, from Udayagiri; additional unnumbered specimens from Laccadive (now Lakshadweep) Islands, Horsleykonda, Chittoor district and Nallamalais, Kurnool district

Hemidactylus reticulatus Beddome, 1870

Material: MAD no number*, from Nallamalai, Kurnool district; MAD 11.16.IX.1923 from Horsleykonda, Chittoor district, "3000-4100 feet", collected by E. Barnes; more unnumbered specimens from Hampi, Bellari district and Sathyavedu, Chingelpet district.

Hemidactylus frenatus Schlegel in: Duméril and Bibron, 1836 *sensu* Smith (1935)

Material: MAD no number, from Laccadive Islands and Coorg.

Hemidactylus leschenaultii Duméril and Bibron, 1836

Material: MAD no number, from Nilgiris.

Hemidactylus giganteus Stoliczka, 1871

Material: MAD 1913*, from Udayagiri droog; MAD no number, labelled as "*Hemidactylus maculatus*" from Collegal.

Agamidae

Draco dussumieri Duméril and Bibron, 1837

Material: MAD no number*, from Coonoor Ghat; additional unnumbered specimens from Kothamangalam, Travancore state and Calicut.

Sitana ponticeriana Cuvier, 1844

Material: MAD no number* (male and female), from Tirupatur, Ramnad district, additional unnumbered specimens from Tirupathi, Ramnad district, and Udayagiri, Nellore district

Remarks: The locality mentioned as 'Tirupathi', may apparently be in error for 'Tirupathur'.

Salea horsfieldii Gray, 1845

Material: MAD no number*, from Nilgiris; MAD 1928 from Bangitapal to Sispara, Nilgiris district, collected by E. Barnes; additional unnumbered specimens labelled as "undetermined agamids" from Ootacamund.

Salea anamallayana (Beddome, 1870)

Material: MAD no number*, from Anamalais; additional unnumbered specimens labelled as "undetermined agamid" from Kodaikanal.

Calotes versicolor (Daudin, 1802) *sensu* Smith (1935)

Material: MAD no number*, from Nilgiris; additional unnumbered specimens from Nallamalai; Madras; Krusadai Islands; MAD11.6.1948/16 from Museum compound.

Remarks: Zug et al. (2006), Manthey (2008), Somaweera and Somaweera (2009) stated *Calotes versicolor* (Daudin, 1802) to be a species-complex.

Calotes nemoricola Jerdon, 1853

Material: MAD no number, labelled as "*Calotes versicolor*?" from Dhoni forest, Malabar.

Calotes grandisquamis Günther, 1875

Material: MAD no number*, from Tinnevelley; another unnumbered specimen from an unknown locality.

Calotes calotes (Linnaeus, 1758)

Material: MAD no number; another unnumbered specimen labelled as "*Calotes ophiomachus*" both from Sirumalais.

Calotes elliotti Günther, 1864

Material: MAD no number*, from Yercaud; more unnumbered specimens from Anaimalais and Thomra, South Coorg, Makut; an unnumbered specimen labelled as "*Carbita leschenaultii*?" from Dhoni forest; MAD 24.V.6.VII.27 collected by E. Barnes, "3000-5000 feet", labelled as 'undetermined agamid' from Netterikkal, Kalakkad forest, Tirunelveli district.

Remarks: This species has not been reported from the Eastern Ghats earlier (Smith, 1935; Das, 2002) and thus, this record from Yercaud is the first. A recent record of this species from Matheran (Manthey, 2008) from Maharashtra far north of its reported range indicates that it may actually be more widespread than currently assumed.

Psammophilus dorsalis (Gray, 1831)

Material: MAD no number*, from unknown locality; additional unnumbered specimens labelled as "*Charsaria dorsalis*" from Nilgiris; Horsleykonda, Chittoor district; Sirumalais; Nallamalais; Kavalai, Cochin state.

Psammophilus blanfordanus (Stoliczka, 1871)

Material: MAD no number*, from Nilgiris; MAD 14.IX.27 collected by E. Barnes, from Tatilanka to Kunavaram, East Godavari district; additional unnumbered specimens labelled as "*Charsaria blanfordanus*" from Jeypur hills; Udayagiri, Nellore district.

Chamaeleonidae

Chamaeleo zeylanicus Laurenti, 1768

Material: MAD no number*, labelled as "*Chamaeleon zeylanicus*" from Madras; MAD 20.12.1951/20, from Museum compound.

Remarks: Somaweera and Somaweera (2009) stated that the taxonomy of this species to be stable, in spite of its many synonyms, although Karunarathna et al. (2009) remarked that the Indian populations may be specifically distinct from that in Sri Lanka.

Scincidae

Eutropis bibronii (Gray, 1838)

Material: MAD no number*, labelled as "*Mabuya bibroni*" from Ramnad; additional unnumbered specimens from Cuddapah hills and Kilakkarai.

Remarks: Smith (1935) and Daniel (2002) mention the distribution of this species from east coast of India and Sri Lanka. The present locality, Cudappah hills, a part of Eastern Ghats, is a significant departure from its typical coastal terrain.

Eutropis carinata (Schneider, 1801)

Material: MAD no number*, labelled as "*Mabuya carinata*" from Madras

Eutropis macularia (Duméril and Bibron, 1839)

Material: MAD no number*, labelled as "*Mabuya macularia*" from Perambikulam; additional unnumbered specimens from Thomra, South Coorg; Dhoni, South Malabar.

Eutropis trivittata (Hardwicke and Gray, 1827)

Material: MAD no number*, from Tirupathur, Ramnad district; MAD 17.IX.1923 labelled as "*Mabuya beddomei*" collected by E. Barnes from Kandiamadagu, Chittoor district, ca. "2500 feet".

Nomenclatural remarks: Though Das et al. (2008) treated all peninsular Indian species previously allocated to the genus *Mabuya sensu lato* as *Eutropis*, this taxon was not included.

Distributional remarks: In Smith's (1935) distribution of this species, Madras was the southernmost locality record. Kalaiarasan (1999) and Kalaiarasan and Kanakasabai (1999) listed this species from Chennai, which is the only precise record of this species from Tamil Nadu. The present specimen from Tirupathur, Ramnad district in the far south of Tamil Nadu is arguably the southernmost record.

Sphenomorphus maculatum (Blyth, 1853)

Material: MAD no number*, and another unnumbered specimen, both labelled as "*Lygosoma maculatum*" from Goomsur, Ganjam district.

Remarks: Smith (1935) gave its distribution as "Eastern Himalayas, N. Bengal, Assam, S.W. Yunnan, Burma, Siam as far south as the Isthmus of Kra, Cambodia, S. Annam, Andaman and Nicobar Is.". Thus, the present record from Gumsur, Ganjam district, in Orissa state of India, is a significant range extension to the south.

Sphenomorphus dussumieri (Duméril and Bibron, 1839)

Material: MAD no number*, labelled as "*Lygosoma dussumieri*" from Travancore, Cochin state; two additional unnumbered specimens from Ernakulam and Courtallam.

Kaestlea bilineata (Gray, 1846)

Material: MAD no number*, and another unnumbered specimen labelled as "*Leiolepisma bilineatum*" from Nilgiris.

Kaestlea palnica (Boettger, 1892)

Material: MAD 1932, labelled as "undetermined Scincidae" collected by F. H. Gravely, from Kodaikanal.

Kaestlea laterimaculata (Boulenger, 1887)

Material: MAD 26.V.VI.27, labled as "undetermined Scincidae" collected by E. Barnes from "3000-5000 feet" in Netterikkal, Kalakkad hills, Tirunelveli.

Ristella rurkii Gray, 1839

Material: MAD no number*, from Anaimalais; MAD 1932 labled as "undetermined Scincidae" collected by F. H. Gravely from Kodaikanal, Palanis.

Ristella beddomii Boulenger, 1887

Material: MAD no number*, from Perambikulam; another unnumbered specimen from Kavalai, Cochin state.

Lygosoma punctata (Gmelin, 1799)

Material: MAD no number*, labelled as "*Riopa punctata*" from Cochin state; MAD 1920 labled as "undetermined Scincidae" collected by F. H. Gravely, and MAD 1924 from Madras; additional unnumbered specimens from Sirumalais and Madras.

Lacertidae

Ophisops leschenaultii (Milne-Edwards, 1829)

Material: MAD no number*, labelled as "*Carbita leschenaultia*" from Tirupathur, Ramnad district, Gumsur, Ganjam district, Udayagiri, Nellore district, Bangalore.

Remarks: The generic name in all labelled specimens is apparently in error (as *Carbita*) for *Cabrita sensu* Gray (1838).

Ophisops minor nictans Arnold, 1989

Material: MAD no number*, labelled as "*Carbita jerdoni*" from Nallamalai; additional unnumbered specimens from Jeypur; Vizag; Kurnool district.

Note: For remarks on the generic name, see *Cabrita leschenaultii* account.

Ophisops jerdoni Blyth, 1853

Material: MAD no number*, from Nallamalai; Kurnool district.

Remarks: Das and Duttagupta (1997) rediscovered its holotype at the Zoological Survey of India, Calcutta.

Varanidae Gray, 1827

Varanus bengalensis (Linnaeus, 1758)

Material: MAD no number*, a juvenile, labelled as "*Varanus monitor*" from Nilgiris; MAD 8.1.1952, an adult from Madras.

SERPENTES
Typhlopidae

Ramphotyphlops braminus (Daudin, 1803)

Material: MAD no number, labelled as "*Typhlops braminus*" from south India; additional unnumbered specimens from Yercaud, Kilakkarai, Sivaganga and Nallamalais; MAD 1956/3 from Madras.

Typhlops beddomei Boulenger, 1890

Material: MAD no number, from Perambikulam; two additional unnumbered specimens from Sirumalais and Cochin.

Remarks: Record from Sirumalai hills, situated further east of the reported localities. Travancore, Animalai hills, Cochin state, Tinnevelly (Smith, 1943) is an additional locality data in the Western Ghats. Smith's (1943) mention of four specimens in British Museum from Kimedy hills, Vizagapatnam indicates a more

widespread, and possibly disjunct, distribution of this rare snake.

Grypotyphlops acutus (Duméril and Bibron, 1844)

Material: MAD no number*, labelled as "*Typhlops acutus*" from Cochin and an additional unnumbered specimen from Chidambaram .

Uropeltidae

Platyplectrurus madurensis Beddome, 1877

Material: MAD no number*, from Pulneys; MAD 1929 and MAD 1932 collected by Gravely from "6000-6800 feet" in Kodaikanal, Palni hills.

Remarks: Smith (1943) records a maximum length of 440 mm; one of our specimens measure 600 mm.

Teretrurus sanguiensis (Beddome, 1877)

Material: MAD no number*, from Perambikulam; an additional unnumbered specimen labelled as "*Platyplectrurus sanguineus*" from Kavalai, Cochin state.

Plectrurus perroteti Duméril, Duméril and Bibron, 1854

Material: MAD no number*, from Nilgiris; MAD 20.30.V.21and MAD 1.14.VII.1928, both determined by F. Wall and collected by F. H. Gravely from "6700-8000 feet" in Ootacamund; an additional unnumbered specimen from Coonoor.

Uropeltis rubromaculatus (Beddome, 1867)

Material: MAD no number*, from Anamalais.

Uropeltis ocellatus (Beddome, 1863)

Material: MAD no number*, from Pe rambikulam; additional unnumbered specimens from Cochin and Kodaikanal, Palni hills.

Remarks: Smith (1943) mentioned that this species is common in Nilgiri and Anaimalai hills, therefore the present record from 'Cochin', in the plains is noteworthy.

Uropeltis pulneyensis (Beddome, 1863)

Material: MAD 1929 six specimens, labelled as "*Uropeltis ocellatus*" collected by E. Barnes,

during April-May, from "6000-6800 feet", Kodaikanal, Palni hills.

Uropeltid grandis (Beddome, 1867)

Material: MAD no number*, from Anamalais.

Uropeltis dindigalensis (Beddome, 1877)

Material: MAD no number*, from Sirumalais, Madura district.

Remarks: Ganesh et al. (2008) listed it from High Wavy Mountains (also in Madurai district), the first record of this species apart from its type locality. However, this taxon is poorly characterized and shares some characters with congeneric taxa, especially *Uropeltis liura,* and a reassessment is needed (David Gower, pers. comm.).

Uropeltis maculatus (Beddome, 1878)

Material: MAD no number*, from Anamalais.

Uropeltis ceylanicus Cuvier, 1829 *sensu* Smith (1943)

Material: MAD no number*, from Perambikulam; an additional unnumbered specimen from Cochin; MAD 1938 labelled as "*Silybura brevis*" from Shevroys; Attikan (Mysore) E. Barne's collection, from ca. "5000 feet", in June 1938; additional unnumbered specimens labelled as "*Silybura brevis*", determined by F. Wall, from Nilgiris, Cochin and Travancore.

Remarks: Gower et al. (2008) resurrected a subjective synonym *Silybura bicatenata* Günther, 1864; remarked that the type locality of *U. ceylanicus* is not "Ceylon" and is endemic to India; its misleading specific epithet along with its rich synonymies originating from northern and southern Western Ghats, emphasizes its unassessed systematic status, and that it is probable that such "subjective synonyms" originating from localities far apart may represent distinct species, now under the name *Uropeltis ceylanicus*. Our specimens from Perambikulam and Cochin, both at 10°N latitude, are consistent in distribution with *Silybura brevis* Günther, 1862 (type loc. Anamallays [Smith, 1943]). The status of *Silybura brevis* as a synonym of *U. ceylanicus* was accepted by Smith (1943) and Whitaker and Captain (2004). Günther's (1864)

localities for the taxon *S. brevis* is only the Anamallais (type locality), but in our case, specimens named as *S. brevis* were obtained from Shevroys (ca. 200 airline km north-east and the type locality of another subjective synonym *S. shortii* Beddome, 1863) and Nilgiris (ca. 200 airline km north-west and the type locality of another subjective synonym *S. nilgherriensis* Beddome, 1863) and Attikan (Mysore) (ca. 250 airline km north and near to the type locality [Wynaad, Malabar], of another subjective synonym *S. nilgherriensis* var. *annulata* Beddome, 1886), and lastly, Cochin. Additionally, Smith (1943) mentioned Ganjam district, Orissa as an erroneous locality for this taxon.

Uropeltis sp.

Material: MAD no number, three specimens labelled as "undetermined Uropeltids from unknown locality".

Remarks: These specimens are in a poor state of preservation and could not be examined.

Rhinophis sanguineus Beddome, 1863

Material: MAD 1937, labelled as "*Silybura brevis*" collected by E. Barnes from High Range.

Rhinophis travancoricus Boulenger, 1892

Material: MAD no number*, from Ernakulam.

Boidae

Eryx johnii (Russell, 1801)

Material: MAD no number*, from Chennai; MAD 24.2.1948, from Diraviyam, Tambaram; MAD 8.1.1952/2, from Madras.

Gongylophis conicus (Schneider, 1801)

Material: MAD no number*, labelled as "*Eryx conicus*" and MAD18.5.1949/5, from Madras; MAD 24.2.1948/64A, from Vandalur; unnumbered specimens from Tambaram, St. Thomas Mt., Chingelpet district and Horsleykonda, Chittoor district.

Acrochordidae

Acrochordus granulatus (Schneider, 1799)

Material: MAD no number*, from Madras; another unnumbered specimen from Krusadai Islands.

Colubridae

Coelognathus helena helena (Daudin, 1803)

Material: MAD no number, labelled as "*Elaphe helena*" from Perambur; MAD 4.2.1954*, from Madras; MAD 15.2.1951, from Tambaram.

Ptyas mucosa (Linnaeus, 1758)

Material: MAD no number*, from Chennai; MAD 13.6.1962, from Museum compound; MAD 26.9.1949, from Tambaram, Chingelpet district; MAD 19.3.1951, from Madras.

Argyrogena fasciolata (Shaw, 1802)

Material: MAD no number*, labelled as "*Coluber fasciolatus*" from Coimbatore.

Remarks: This specimen is in a poor state of preservation.

Liopeltis calamaria (Günther, 1858)

Material: MAD 28-31-VII-22, labelled as "*Ablabes calamaria*" collected by F. H. Gravely from "200-800 feet" in Kambakkam hills, Chingelpet district.

Remarks: The present specimen from Kambakkam hills, Chingelpet district, is the first record of this species from these hills (see Smith, 1943).

Oligodon venustus (Jerdon, 1853)

Material: MAD no number*, from Nilgiris.

Oligodon taeniolatus (Jerdon, 1853)

Material: MAD 11.5.1955*, labelled as "*Oligodon subgriseus*" and MAD 23.5.1957 from Madras; two unnumbered specimens, from Dhoni forest, Malabar and an unnumbered specimen labelled as "*Oligodon elliotti*" from Kunavaram, East Godavari district.

Remarks: Bauer (2003) declared *Oligodon taeniolatus* (Daudin, 1803) as *nomen oblitum* and its junior synonym and secondary homonym *Oligodon taeniolatus* (Jerdon, 1853) as *nomen proctectum* and these two nomina were made objective synonyms by his lectotype designation.

Oligodon arnensis (Shaw, 1802)

Material: MAD 1925, labelled as "*Simotes arnensis*" from Perambur and another specimen from Kilpauk, MAD 2.10.1947, from Madras, collected by F. Thomas of Binny and Company; an additional unnumbered specimen* from Nallamalai.

Dendrelaphis grandoculis (Boulenger, 1890)

Material: MAD no number*, from Wynaad.

Dendrelaphis tristis (Daudin, 1803) *sensu* Whitaker and Captain (2004)

Material: MAD 12.6.1962, labelled as "*Ahaetulla tristis*" from Museum compound; MAD 3.5.1941, labelled as "*Dendrophis pictus*" from Adyar, Madras, collected by H. Heechan King Fair Haven; MAD 24.2.1948, labelled as "*Dendrophis picta*" from Vandalur ; MAD no number, from Adyar, Madras; MAD no number, labelled as "*Dendrophis pictus*" from Palghat; MAD 1942, from South Lagoon, Krusadai Islands.

Remarks: *Dendrelaphis tristis sensu stricto* is based on its neotype, SMF 58442 from Calcutta (= now Kolkata, West Bengal state, India) housed in Natur-Museum und Forschungs-Institut, Senckenberg, Frankfurt-am-Main, Germany (Rooijen and Vogel, 2008). The south Indian population is being reassesed (Gernot Vogel pers. comm.).

Chrysopelea ornata (Shaw, 1802)

Material: MAD no number, from Anaimalai.

Lycodon travancoricus (Beddome, 1870)

Material: MAD 4.3.1941, from Coonoor, Naduvattam in Nilgiris, collected by G.W. Easton.

Lycodon aulicus (Linnaeus, 1758) *sensu* Whitaker and Captain (2004)

Material: MAD 17.3.1950, from Gopalapuram, Madras; MAD 1965 labelled as "*Lycodon venustus*", from Museum compound; MAD 15.12.1954, from unknown locality; MAD 28.7.1944, from Museum compound; MAD 9.9.1948, from Madras; MAD 5.12.1953, labelled as "*Lycodon* sp." from Madras, presented by Mr. Duffy; MAD 17.8.1957, from Madras.

Dryocalamus nympha (Daudin, 1803)

Material: MAD 1950/9, from Pallavaram; two additional unnumbered specimens from Tambaram and Madras. Kucharzewski & Tillack (2008) synonymised the purported neotropical species *Cochilophagus isolepis* Müller, 1924 with *Dryocalamus nympha*; and also designated & redescribed BMNH1946.1.1.13.69 as the lectotype of *D. nympha*.

Sibynophis subpunctatus Duméril, (Duméril and Bibron, 1854)

Material: MAD no number, labelled as "*Polydontophis sagittarius*" from Udayagiri, Nellore district

Remarks: Captain et al. (2008) reassessed the systematic status of *Sibynophis subpunctatus* and *S. sagittarius* and considered them distinct, with parapatric ranged. Our specimen from Udayagiri, Nellore district, is more likely to be *Sibynophis subpunctatus* as its locality is far south of *S. sagittarius*.

Xenochrophis piscator (Schneider, 1799) *sensu* Whitaker and Captain (2004)

Material: MAD17.6.1955*, labelled as "*Natrix piscator*" from Madras; MAD 17.10.1950 and MAD 9.1.1948, labelled as "*Tropidonotus piscator*" from Madras and Vandalur; an additional unnumbered specimen from Yercaud.

Remarks: Vogel and David (2006) stated that *Xenochrophis piscator* (Schneider, 1799) is a species-complex, containing *X. piscator sensu stricto* and an undescribed species *Xenochrophis* sp., which is distributed in extreme southern India and Sri Lanka.

Amphiesma stolatum (Linnaeus, 1758)

Material: MAD no number, labelled as "*Natrix stolatum*" from Madras; an unnumbered specimen from unknown locality; MAD 15.12.1957/14, labelled as "*Ahaetulla tristis*" from Madras, received from Mr. Duffy, Nungambakkam, Madras.

Amphiesma monticola (Jerdon, 1853)

Material: MAD no number, labelled as "*Tropidonotus monticola*" from an unknown locality.

Amphiesma beddomei (Günther, 1864)

Material: MAD no number, labelled as "*Natrix beddomei*" from an unknown locality; additional unnumbered specimens labelled as "*Tropidonotus beddomei*" from Dhoni forest, Palghat.

Macrophisthodon plumbicolor (Cantor, 1839)

Material: MAD no number*, from Parambikulam; additional unnumbered specimens from Tamtam, Pulneys, Attikken, Yercaud, Sirumalais, Bangalore and Mysore.

Atretium schistosum (Daudin, 1803)

Material: MAD no number, from Madras; MAD 24.2.1948, labelled as "*Helicops schistosum*" from Vandalur.

Xylophis perroteti (Duméril and Bibron, 1854)

Material: MAD 1935, from Stoney R. F., Ootacamund ca. "6250 feet"; MAD 9.7.1937, from Nilgiris, collected by E. Madhavan, Fish Inspector, Ooty; an additional unnumbered specimen labelled as "*Chrysopela ornata*" from Anaimalai hills.

Xylophis stenorhynchus (Günther, 1875)

Material: MAD no number, from an unknown locality.

Remarks: Gower and Winkler (2007) redefined this species after recognizing *X. captaini* Gower and Winkler, 2007 and considered *X. indicus* Beddome, 1878 to be a putative subjective synonym of *X. stenorynchus* (Günther, 1875).

Boiga trigonata (Schneider, 1802)

Material: MAD no number*, from Madras.

Boiga ceylonensis (Günther, 1858)

Material: MAD no number*, from Coonoor; additional unnumbered specimens from Pillalur, Nilgiris district and Palghat.

Boiga sp.

Material: MAD 1913, labelled as "*Dendrophis pictus*" from Udayagiri, Nellore district.

Remarks: This specimen closely resembles *Boiga beddomei* (Wall, 1909), but for a lower subcaudal count, anterior temporal and supralabials touching eye. Recently, the holotype of *Boiga ranawanei* Samarawickrama, Samaraw-

ickrama, Wijesena and Orlov, 2005 was designated as the neotype of *Boiga beddomei,* despite the discrepencies in preoculars and anterior temporal, thus making *B. ranawanei* an objective junior synonym of the former (Manamendra-Arachchi and Pethiyagoda, 2007). Secondly, its distribution is also unclear. The type localities of the seven syntypes are: Matheran in Western Ghats of India for one specimen, Kandy in central Sri Lanka for another and Ceylon (now Sri Lanka) for the remaining five specimens (Manamendra-Arachchi and Pethiyagoda, 2007). Thus, there is no syntype originating from a precisely-named, dry zone habitat-locality, both in India and Sri Lanka. Das and de Silva (2005) gave only north-western coastal arid scrub zone for the Sri Lankan distribution of *B. beddomei,* thereby disregarding one of the type localities-Kandy in central Sri Lanka. This species has been recorded from Matale, near Kandy (Ruchira Somaweera pers. comm.). Sivakumar and Manakandan (2007) reported "*B. beddomei*", (a Western Ghats species), from Nellore district where our specimen comes from. They stated that the snake was greenish-brown in colour and was on *Casuarina* trees along sandy beach stretch, quite inconsistent with the data in the literature (Whitaker and Captain, 2004). It is probable that the north-western Sri Lankan and Eastern peninsular Indian regions both share a *B. beddomei*-like species and that Das and de Silva (2005) refer to the Sri Lankan population of this species as *B. beddomei,* due to lack of consensus on its identity and distribution.

Ahaetulla perroteti (Duméril and Bibron, 1854)
    Material: MAD no number, labelled as "*Dryophis perroteti*" from The Kundalu; additional unnumbered specimens from Nilgiris.

Ahaetulla nasuta (Lacépède, 1789) *sensu* Whitaker and Captain (2004)
    Material: MAD 9.1.1948, MAD 6.5.1952, MAD 18.12.1952 and MAD July 1964 labelled as "*Dryophis mycterizans*"from Madras; MAD 7.7.1948, MAD 15.4.1955, MAD 3.12.1957, MAD 25.9.1959, MAD 3.12.1957, MAD 1934, MAD 1960 and MAD 1966, labelled as "*Dryophis nasutus*" from Madras; and MAD 1941, labelled as "*Dryophis nasutus*" from Palghat.

MAD no number labelled as "*Dryophis dispar*" from Coorg.

Cerberus rynchops (Schneider, 1799)
    Material: MAD 25.6.1955, from Adayar (in Chennai); MAD 17.3.1958; two additional unnumbered specimens from Madras; an unnumbered specimen from Krusadai Islands.

Elapidae

Bungarus fasciatus (Schneider, 1801)
    Material: MAD18.11.1955, from Madras Zoo; an additional unnumbered specimen from Travancore.
    Remarks: Distribution of this species in 'Travancore' is erroneous (Smith, 1943; Whitaker and Captain, 2004).

Bungarus caeruleus (Schneider, 1801)
    Material: MAD 4.12.1951, from an unknown locality; MAD 19.12.1949, from Tambaram and MAD 26.11.1952 and an unnumbered specimen*, from Madras.

Calliophis melanurus (Shaw, 1802)
    Material: MAD 30.3.1948/10, from Tambaram, Diraviyam, Chengelpet, donated by Christian College attender; two additional unnumbered specimens from Tiruchirapalli district and Madras.

Calliophis sp.
    Material: MAD no number; labelled as "*Calliophis bibroni*" from Wynaad.
    Remarks: The material is in a poor state of preservation. Additionally Smith et al. (2008) did not consider this specimen as a *Calliophis bibroni* doubting its identity as mentioned in the bottle.

Naja naja (Linnaeus, 1758)
    Material: MAD no number*, from an unknown locality; MAD 5.5.1943 and MAD 19.11.1952, labelled as "*Naia tripudians*" from Museum compound; MAD 29.11.1947, from Vandalur, collected by Presidency College Lab Assistant; MAD 24.4.1950, MAD 10.5.1950, MAD 20.12.1951and MAD 23.9.1954, from Madras.

Ophiophagus hannah (Cantor, 1836)

Material: MAD no number*, a juvenile, labelled as "*Naja hannah*" from Bellary and another unnumbered adult specimen from Travancore.

Remarks: Distribution in Bellary is dubious (Smith, 1943; Whitaker and Captain, 2004).

Hydrophiidae

Kerilia jerdoni Gray, 1849

Material: MAD no number*, labelled as "*Hydrophis jerdoni*" from Chennai.

Remarks: *Hydrophis jerdoni* is a novel (and unavailable) name combination for this species.

Enhydrina schistosum (Daudin, 1803)

Material: MAD 1917* and MAD 20.5.948, labelled as "*Enhydrina valakadyn*" from Madras Harbour.

Hydrophis spiralis (Shaw, 1802)

Material: MAD no number* from Madras; MAD 16.4.1944, from Mahabalipram, collected by K. S. Sreenivasan; MAD 7.9.1944, from Porto Novo, collected by Joshua, Christian College; MAD 1944 from Krusadai Islands.

Hydrophis obscurus Daudin, 1803

Material: MAD no number*, from 'Sea Snake Lake'; MAD 17.4.1952 from Ennore backwaters.

Hydrophis gracilis (Shaw, 1802)

Material: MAD no number*, from Madras.

Lapemis curtus (Shaw, 1802)

Material: MAD no number*, from Madras .

Pelamis platura (Linnaeus, 1766)

Material: MAD no number*, from Madras; another unnumbered specimen from Krusadai Islands.

Viperidae

Daboia russelii (Shaw and Nodder, 1797)

Material: MAD 9.5.1949*, labelled as "*Vipera russelii*" from Madras

Echis carinatus carinatus (Schneider, 1801)

Material: MAD no number*, from Madras; MAD 28.6.1944 from Poona; MAD 1.8.1949/12, MAD 8.9.1952 and MAD 24.12.1952 from Madras; two unnumbered specimens from Tambaram, Chingelpet district.

Remarks: Our specimens are from southern India, and are thus *Echis carinatus sensu stricto* (Pook et al., 2009).

Hypnale hypnale (Merrem, 1820)

Material: MAD 16.7.1966*, from Coimbatore, received from M. A. Badsha, State Wildlife Office, Madras; unnumbered specimens from Trichur, Cochin state; Palghat; Travancore.

Remarks: Maduwage et al. (2009) revised this genus and redescribed *Hypnale hynale* based on the neotype BNHS 2531:759 from Castle Rock, Karnataka, India.

Trimeresurus macrolepis Beddome, 1862

Material: MAD no number*, from Pulneys; MAD 10.8.1940 from Shenbaganur, collected by Father Guthrie; an unnumbered specimen from Shenbaganur with a label that it was identified by Dr. Malcom Smith.

Trimeresurus malabaricus (Jerdon, 1854)

Material: MAD no number*, from Palghat; more unnumbered specimens from Dhoni forest and Anamalai hills.

Trimeresurus strigatus Gray, 1842

Material: MAD no number*, from Nilgiris.

Remarks: Smith (1943) mentioned of a variation in a specimen from Coonoor in this museum, having its second labial united with the shield forming the anterior wall of loreal pit.

Trimeresurus gramineus (Shaw, 1802)

Material: MAD no number*, labelled as *Trimeresurus gramineus* from Coonoor.

Specimens not Traceable Presently

The following are specimens that were recorded by Thurston (1888) in this museum, but could not be traced at present (catalogue numbers not given in Thurston, 1888): *Ichthyophis glutinosus* from Wynaad; *Uraeotyphlus oxyurus* from Malabar; *Bufo* (now *Duttaphrynus*) *melanostictus* from Cochin, Ootacamund and Kotagiri;

Bufo (now *Duttaphrynus*) *microtympanum* from Kodaikanal, Pulney Hills; *Melanobatrachus indicus* from Anamallays; *Callula* (now *Ramanella*) *triangularis* from Ootacamund; *Microhyla ornata* from Tinnevelly; *Callula* (now *Uperodon*) *systoma* from Nilgiris; *Ixalus* (now *Philautus*) *signatus* from Pycara and Coonoor (Nilgiris); *Ixalus* (now *Philautus*) *glandulosus* from Kotagiri; *Ixalus* (now *Philautus*) *femoralis* from unknown locality; *Ixalus* (now *Micrixalus*) *saxicola* from Malabar; *Rhacophorus* (now *Polypedates*) *maculatus* from Shevaroys; *Rhacophorus pleurostictus* (now *Ghatixalus variabilis*) from Nilgiris; *Rana* (now *Hylarana*) *temporalis* from Anamallai and Nilgiri; *Rana* (now *Clinotarsus*) *curtipes* from Wynaad; *Rana* (now *Hylarana*) *malabarica* from Malabar; *Rana* (now *Sphaerotheca*) *breviceps* from Tinnevelly; '*Rana gracilis*' (*incertae sedis*) from Nilgiris; *Rana* (now *Hoplobatrachus*) *tigerinus* from Nilgiris; '*Rana kuhli*' from Nilgiris (incertae sedis) and *Rana* (now *Euphlyctis*) *hexadactyla* from an unknown locality.

Acknowledgements

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First record of *Amphiesma venningi* (Wall, 1910) (Serpentes, Colubridae, Natricinae) from Bangladesh, with notes on its taxonomy, natural history, biogeography and other sympatric species

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(with four text-figures)

ABSTRACT.– The poorly known natricine snake *Amphiesma venningi* (Wall, 1910), previously reported only from upper Myanmar, southern China and north-eastern India, is added to the herpetofauna of Bangladesh on the basis of an adult specimen collected from the Kaptai National Park, southeastern Bangladesh. Description of the live specimen, scalation patterns and natural history notes are presented with colour photographs. A brief description on the country's other sympatric species with their biogeographical implications and an identification key of the recorded species is provided.

KEY WORDS.– Natricinae, taxonomy, *Amphiesma venningi*, Kaptai National Park, Bangladesh.

Introduction

The genus *Amphiesma* consists of small to moderately large, terrestrial to semi-aquatic, oviparous and harmless snakes, that are distributed throughout southern, eastern and south-eastern Asia, ranging from Pakistan and India to eastern China, north into southernmost Russia and Japan, and southwards to Sumatra and Sulawesi (Cox, 1991; Malkmus et al., 2002). Among 41 nominal species (David and Das, 2003; David et al., 2007) of the genus *Amphiesma*, up to five are reported from Bangladesh in the literature (Kabir et al., 2009; Khan, 2008; Whitaker and Captain, 2004; Khan, 2004; IUCN Bangladesh, 2000; Ahsan, 1998; Das, 1994): *Amphiesma khasiense* (Boulenger, 1890), *A. platyceps* (Blyth, 1854), *A. sieboldii* (Günther, 1860), *A. stolatum* (Linnaeus, 1758), and *A. xenura* (Wall, 1907). However, most of the country's species lists are neither based on systematic collections nor published in peer-reviewed journals and species records are rarely supplied with locality data and/or photographic

references. Without such basic information, it becomes virtually impossible to cross-check the proper taxonomic identity and distributional range of the species (Mahony and Reza, 2008). The most recent account of the country's reptiles is provided by Kabir et al. (2009) and mentioned only four *Amphiesma* species, with one new country record, *A. xenura* (Chakma, 2009). This species has previously been reported from both the Khasi Hills (Smith, 1943) and Naga Hills (Romer, 1945), both in north-eastern India. Recent surveys have also found them in Mizoram, India (Pawar and Birand, 2001) and Rakhine Hills of Rakhine State, Myanmar (Wogan et al., 2008). Among others, *A. stolatum* is widely distributed throughout the country (Chakma, 2009; Das, 2008; Whitaker and Captain, 2004). *A. platyceps* has been cited as 'rare in Bangladesh' but reported from the northern part of the country (Chakma, 2009) which needs to be confirmed. For the remaining *Amphiesma* species in Bangladesh, no specimen-based evidence and photographs are

available to re-assess their distribution in the country.

Some species of *Amphiesma* are poorly diagnosed and also variable that identification of populations may be difficult (David et al., 2007) and are subject to numerous prolonged taxonomic debates. Further studies are undoubtedly needed to clarify the generic allocation of some poorly defined species of this genus (David et al., 2005). The affinities of *Amphiesma* species are still unclear owing to the lack of phylogenetic analyses (David et al., 2007). The Chin Hills Keelback, *Amphiesma venningi*, was described from the Haka region of the Chin Hills of Myanmar and initially named *Tropidonotus venningi* (Wall, 1910) and later referred to as *Natrix venningi* (Wall, 1926). The species was subsequently recorded from few other locations in northern Myanmar (Chin and Kachin State), southern China (Jinhong and Mengla in Yunnan Province) and northeast India (Arunachal Pradesh and Meghalaya States) (Smith, 1943; Dowling and Jenner, 1988; Kou, 1985; Zhao and Adler, 1993; Captain and Bhatt, 2001). Gayen (2001) reported a specimen of *A. venningi* from Jayantia Hills of Meghalaya State, India which was later argued by Mathew and Meetei (2004) where they suggested the correct taxonomic identity of the specimen as *A. xenura*.

Recent herpetological surveys in Bangladesh have resulted in several new country records as well as range extensions of amphibians and reptiles in Bangladesh (Reza and Mahony, 2007; Mahony and Reza, 2007a, 2007b, 2008; Reza, 2008a, 2008b, 2008c; Reza, 2009). Kaptai National Park, a hilly evergreen forest of 5,464 ha in the south-eastern Bangladesh, has been selected as one of the several other sampling sites for this study. Fieldwork was carried out mostly in summers for at least three months since 2006, with some additional trips in other seasons to note the seasonal variations. In the course of this herpetofaunal survey in Bangladesh, in summer 2008, I collected a moderate-sized natricine snake inside the Kaptai National Park and was later transported to the Department of Zoology laboratory at Jahangirnagar University, Bangladesh. The specimen was later identified as an adult *Amphiesma venningi* (Wall, 1910), a species not yet recorded from the country. The specimen is described in detail, and compared with the original description and other materials, with notes on its scalation patterns, colouration, natural history, and habitat description. A brief description of the country's other sympatric species, with biogeographical implications and an identification key for the Bangladeshi *Amphiesma* is provided.

Materials and Methods

The snake was hand collected and carried in a snake bag to the field station. It was kept alive for the next five days in a plastic jar before it was euthanized following standard protocol. Several images were taken in life with a Nikon™ D70S camera fitted with a 60 mm micro lens mounted with a ring-flash. The specimen was fixed in 10% buffered formalin and transferred to 70% ethanol and temporarily stored in the Zoological Museum of the Department of Zoology, Jahangirnagar University where it was assigned a field number (JU 0116). A measuring tape was used to measure body length (SVL and tail length, TaL) and a digital vernier caliper for other body dimensions (least count 0.01 mm, rounded off to the nearest 0.1 mm). Details of scalation patterns were observed using a 10X magnifying glass. The terminal scute is excluded from the number of subcaudals. The number of dorsal scale rows is given at one head length just behind the head, at midbody (i.e., at the level of the ventral plate corresponding to half of the total number of ventrals), and at one head length before vent, respectively. Ventral scales were counted according to Dowling (1951).

Abbreviation. CAS: California Academy of Sciences; BMNH: British Museum of Natural History; JU: Jahangirnagar University; SVL: Snout-vent Length; TaL: Tail Length;

Results

Location.– An adult snake (JU 0116) was collected at about 21:45 h on 4 June 2008, on a forest trail close to a natural hill stream inside the Kaptai National Park of southeastern Bangladesh. Related geographic data for the collection site is: Bangladesh, Rangamati District, Kaptai National Park (22°30'56"N, 92°12'57"E, WGS 84) at an elevation of 260–290 m. There was isolated thunderstorm and heavy rain most of the whole week and the relative humidity of the day

was recorded as 91%. Wind speed, on an average, was 1.6 km/h.

Kaptai National Park is one of the 19 protected areas of Bangladesh and was established in 1999, covering an area of 5,464 ha of hilly evergreen forest, in Rangamati District. The Park is a part of Chittagong Hill Tracts, situated in south-eastern Bangladesh and is the only true mountainous region in the country. These mountains run in a north to south direction forming parallel ridges with deep narrow valleys. The range continues north to form the hill ranges of Tripura and extend south to the coast in the western Rakhine District of Myanmar. In the east, it is contiguous with the Mizo Hills of Mizoram, India, and the Chin Hills of Myanmar. The area until fairly recently consisted of mixed evergreen forests with an abundance of bamboo and other undergrowth. Considerable amount of natural habitat has now been cleared by anthropogenic activities, such as unplanned logging and *jhum* (slash and burn) cultivation. However, small isolated patches of natural forests remain, which seem to be the last stronghold for many species.

Description of specimen.– The adult specimen is slender bodied, with head broader than neck. SVL 393 mm and the TaL 121 mm, which is smaller than the most other population recorded elsewhere (Wall, 1910; Venning, 1911; Smith, 1943; Captain and Bhatt, 2001). The upper part of body blackish-brown with indistinct dark spots and an incomplete pale collar (Figs. 1–2). No prominent red ventral colouration in life other than light orange belly with pale yellow ventral scales towards the mid-body. Snout long, slightly flattened, distinct and feebly keeled upper row scales with smoother outer rows. Head moderate and marbled with black and grey, two parietal scales are distinctly marked with crimson colour (Figs. 2–3). Upper lip scales are brownish-white and their posterior margins edged with black bands. Yellow chain-like markings on the sides. Ventral side of the hind body blackish especially towards the tail (Fig. 4), but becoming more and more mottled with greyish to dirty white towards the throat. Most subcaudals are light-brown with black smudges near their outer edges; the posterior subcaudals are darker than the anterior ones. The large eye has a round pupil. Tongue
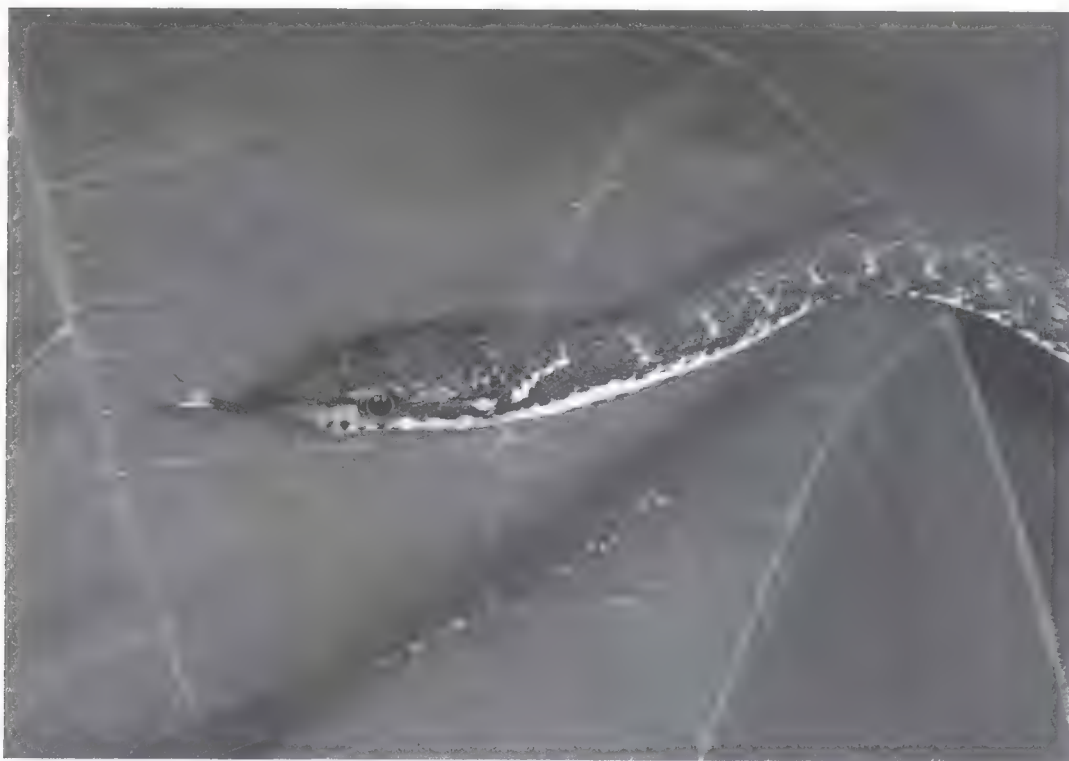
mostly black, and pale brown towards the tip (Fig. 2).

Body and head scalation.– The Bangladesh sample has a constant number of 17 dorsal scales throughout the body, which are distinctly keeled. Anal is divided. Total ventral scale count is 163, and there are 103 paired subcaudal scales. Smith (1943) described *A. venningi* subspecies as: *Natrix v. vennigi* 117–140 subcaudal and 158–172 ventrals, whereas *Natrix v. taronensis* 84–106 subcaudals and 166–176 ventrals. This taxonomy has been followed by Captain and Bhatt (2001), but the Bangladesh sample does not match any subspecies descriptions. It has broader head than the neck with dorsolateral nostril and 9 supralabial scales. Two preoculars, 3 postoculars and a large supraocular (numbers are equal in both sides). 1+1 temporals (1 anterior and 1 posterior) before the neck. Considering the subspecies description by Smith (1943), the Bangladesh specimen is closer to *A. v. venningi* with few extra subcaudal scales and may be placed under this subspecies.

Natural History.– The snake was found on a forest trail close to a natural hill stream, ca. 500 m north of the Bangladesh Forest Industries Development Corporation (BFIDC) Officer's Dormitory inside Kaptai National Park. The forest type could be described as hilly mixed evergreen forest (sometimes also referred to as tropical evergreen forest) dominated by *Tectona grandis* plantation. Other native plants in the area include: *Dipterocarpus turbinatus, Mangifera sylvatica, Hopea odorata* with climbers such as *Calycopteris floribunda, Dioscorea pentaphylla* and *Bridelia retusa*. There were several wild bamboo tracts around the vicinity. The snake was found active at night (~21:45 h) on the ground, which apparently actively searching for prey. When approached, it was inoffensive and while being handled, did not attempt to bite. Before euthanizing for collection, it was kept alive for five days in a plastic jar. It did not take any food for the first three days, though supplied with three different types of prey item: *Microhyla ornata, Hemidactylus frenatus* and tadpoles of *Fejervarya* sp. Live animals were given inside the jar and kept inside for 5–10 min and if there was no sign of interest, the live prey animals were taken out. On the fourth day, the snake ate a small *Microhyla ornata* immediately

Figure 1. Dorsolateral view of entire body of *Amphiesma venningi* in life from the Kaptai National Park, south-eastern Bangladesh.

Figure 2. Dorsolateral view of head and neck of *Amphiesma venning* in life. Note tongue colour (mostly black, basally paler, with pale brown towards tip).

Figure 3. Dorsolateral view of head and fore-body of *Amphiesma venningi* in life. Note the two distinct crimson marked parietal scales and the light-coloured mark on the neck.
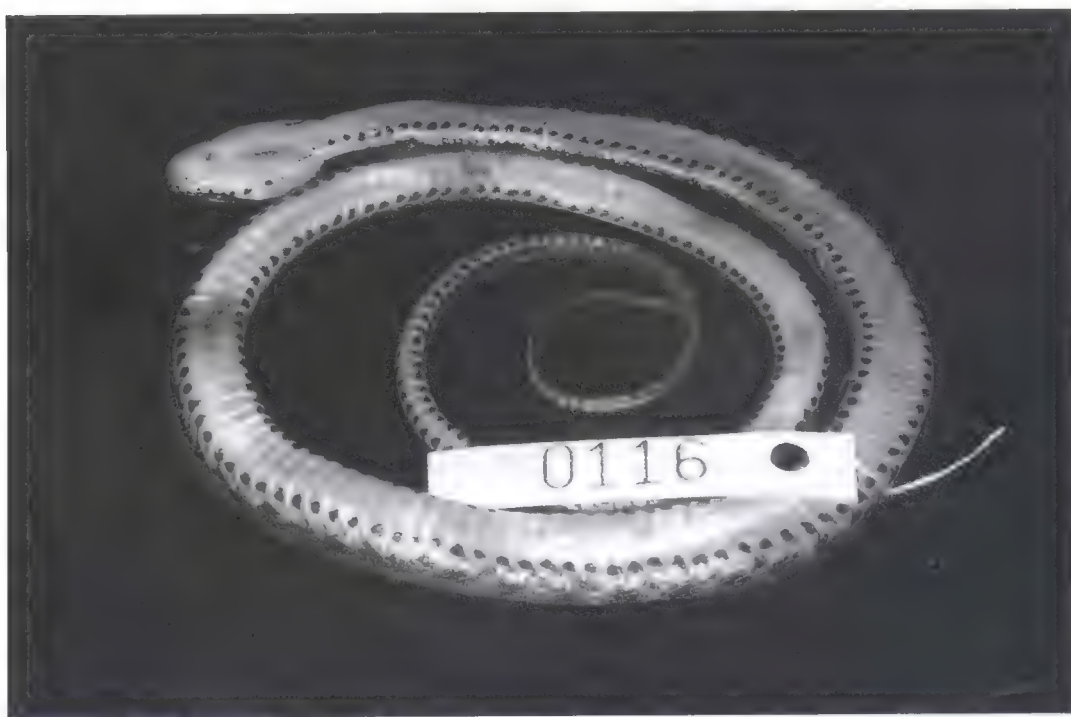
Figure 4. Ventral view of body of preservation specimen (JU 0116) of *Amphiesma venningi*. Note brown-black subcaudals with pale yellow ventrals.

after it was introduced into the jar. The snake did not take any other food before it was euthanized on the fifth day.

Discussion

Patrick David confirmed the identification of the specimen from Bangladesh as *A. venningi*. The sample matches the most important separable characteristic for this species: the constant number of 17 dorsal scales throughout the body. Captain and Bhatt (2001) mentioned the presence of striking coral red ventral colouration in the Indian population. However, the Bangladeshi specimen does not have this noticeable colouration on venter, which is said to be variable in recent collections from Myanmar (G. Wogan, pers. comm.) and not been reported from most of the previous specimens from Myanmar and China (Venning, 1911; Wall 1910; Smith, 1943; Kao, 1985). One reason could be because many previous workers (Wall, 1910; Smith, 1943; Kou, 1985) never saw live specimens (Captain and Bhatt, 2001) and in preserved specimens, the prominent red colour of life turns into light grey rapidly. However, examining at least three of the live snakes collected from Myanmar, Venning (1911) did not mention the red ventral coloration in the specimens he described. With the Bangladesh population discovered with no prominent red ventral colouration, the idea that the Indian population could be another undescribed taxon (Captain and Bhatt, 2001) receives some support. However, variation within the genus *Amphiesma* are often subtle and need further investigation, and possibly a molecular phylogenetic approach would be relevant.

Having personally examined a couple of *A. venningi* specimens (CAS 233206 and CAS 234777) originating from the Haka and Kanpatlat Township of Chin State, Myanmar, it is clear that the Bangladesh sample matches most of its external characteristics, colouration and scalation patterns of this Myanmar population. The Chin State in Myanmar is geographically closer to the Bangladesh sample site (<160 km east) than the Kachin samples (CAS 238901 and CAS 238902), which have a variable red ventral colouration (G. Wogan, pers. comm.). The Kachin samples are much closer to the Indian population (~160 km south) than the origin of Bangladesh sample (>800 km south-east) and

share similar colour patterns. With this colour variation in samples originating from different geographic ranges as well as the inconsistent subcaudal and verntral scale counts, it is difficult to differentiate between the two described subspecies of *A. venningi*. As Captain and Bhatt (2001) doubted the validity of subspecies *A. v. taronensis*, I recommend a reevaluation of the subspecies description with molecular evidence. While preparing this manuscript, I noticed that *A. taronensis* has been considered a distinct species (California Academy of Sciences, 2009). Therefore, until further evidence come in, I suggest considering the Bangladesh and Chin Hills population as *A. v. venningi*.

After examining the available literature and previous distribution records of the genus *Amphiesma*, four species (*A. platyceps*, *A. stolatum*, *A. xenura* and *A. venningi*) occur in Bangladesh, with a possibility of a fifth one (*A. khasiense*) that needs to be confirmed. An identification key is provided below to help identify the described Bangladeshi *Amphiesma* species. Among the four species from the country, *A. stolatum* is the most common and shows significant colour variation. The south Asian endemic, *A. platyceps* has been recorded from the northern part of Bangladesh (Das, 1994; Kabir et al., 2009). A similar species, *A. sieboldii*, has been synonymized with *A. platyceps* as most of the characters broadly overlap (Tillack, 2003). The third endemic south Asian species, *A. xenura* is not common and only found in the hilly areas of the country from where it was first reported recently (Chakma, 2009). This new country record was previously been described from both the Khasi Hills (Smith, 1943) and the Naga Hills (Romer, 1945) in north-eastern India. Recently, this species has also been reported from Mizoram, India (Pawar and Birand, 2001) and the Rakhine Hills of Myanmar (Wogan et al., 2008). This report confirms the occurrence of a fourth species *A. venningi* from Bangladesh. The fifth and an unconfirmed species from Bangladesh, *A. khasiense*, was initially described from Khasi Hills in India (Boulenger, 1890) but also been reported from Myanmar, Thailand, Laos, Vietnam, and China (Das, 2008 ; David et al., 2007).

Biogeographically, Bangladesh is situated between the Indo-Himalayan and Indo-Chinese sub-region of the subtropical Oriental region.

On one hand, the tropics have some of the fastest rates of degradation of natural land cover, while on the other, they are generally data-poor and cash-strapped (Myers et al., 2000; Mittermeier et al., 2004). This is obviously true in case of Bangladeshi amphibians and reptiles as they are poorly known with limited survey data. The present study site, the Kaptai National Park, is a part of Chittagong Hill Tracks which is a centre of herpetological biodiversity of the country. The dominance of south-east Asian genera in this area may be due to the raising and lowering of sea levels during the Pleistocene (Zug et al., 2006), which most likely provided a lowland bridge at the southern extremity of the Indo-Myanmar mountain range. This lowland bridge would have allowed the movement of many south-east Asian species into Bangladesh and vice-versa. Also the presence of the Brahmaputra River in the northeastern part of Bangladesh might form an important biogeographical barrier to the eastern expansion of certain species. However, this school of thought and extent of geographic distribution of many species is presently difficult to assess due to the lack of knowledge on confirmed species ranges within Bangladesh. Much more field research is required of Bangladesh, especially the Chittagong Hill Tracts, to assess the true herpetological diversity of this area. As much of the original forest habitat in the Chittagong Hill Tracts of Bangladesh has now been cleared, a higher emphasis must be made for conserving what remains.

Key to the reported *Amphiesma* species of Bangladesh
This key is based on Boulenger (1890), Smith (1943), Whitaker and Captain (2004), David et al. (2007) and Das (2008), as well as my own observations in the field and based on museum specimens. Unconfirmed species reports from Bangladesh are placed in brackets.
1. 17 scale rows at midbody. . . . .
. . . .*Amphiesma venningi*
19 scale rows at midbody. 2
2. Subcaudals single. . . *Amphiesma xenura*
Subcaudals paired 3
3. Ventral scales over 160 . . . .
. . . .*Amphiesma platyceps*
Ventral scales under 160 4

4. Dorsal pattern with two distinct ribbon-like yellowish stripes from neck to tail tip on a grey, ochre, tan, or pale brown background . . . .*Amphiesma stolatum*
Dorsum dark greyish-brown, with faint dorsolateral rusty-brown stripe, on which are aligned rusty spots . . . .
. . . .(*Amphiesma khasiense*)

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An ecological study on *Chiromantis simus* (Anura: Rhacophoridae), with special reference to breeding behaviour at Rajpur, eastern India

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(with 13 text-figures)

ABSTRACT.– The rhacophorid frog, *Chiromantis simus* was rediscovered at Rajpur, West Bengal, eastern India, 84 years after its description from Assam State. I report the breeding behaviour of *C. simus* at a small cemented water pool, between the years 2008–2010. Two distinct calls were recorded- an advertisement call and an aggressive call, and their sonograms presented. A total of 67 foam nests were made per year on average, that were associated with leaves of 13 different plant species and on three inanimate objects. *C. simus* were regularly seen sitting between 6–9 m on the canopy, and made a number of nests there. The nesting period was 87 days per year on average, from the beginning to end of the monsoon season. Maximum number of nests was made at 2300 h. During amplexus, females selected the nesting leaf and male jumped on females. Amplexus involving multiple males was regularly observed. Generally, frogs took one hour to complete a foam nest. Often, the female covered the egg mass with additional layers of foam and those nests became rufous in colour after a day. Tadpoles of *C. simus* were fond of Jackfruit leaves. Some tadpoles from the late monsoon overwintered. Predation by the Giant Crab Spiders Dytiscidae beetles and larvae of Diptera were recorded on adults, tadpole and foam nest stages, respectively.

KEY WORDS.– Amphibia, *Chirixalus, Chiromantis simus*, ecology, foam nesting, multiple amplexus.

INTRODUCTION

The genus *Chiromantis* includes four species in India, which were until recently allocated to *Chirixalus*: *C. doriae* from Arunachal Pradesh, that breeds in grassy marshland (Wen hao et al., 2004), *C. dudhwaensis* from Uttar Pradesh that breeds on *Ipomea carnea* (Biswas, 2000), *C. simus* from Assam and West Bengal, which is associated with grassy marshlands (Deuti, 2001) and *C. vittatus* from Nagaland and Mizoram, that makes a gelatinous nest on grassy marshes (Deuti and Dutta, 2002). Reproductive diversity in the genus may reflect a lack of close relationship among different members of this group (Frost et al., 2006). Perceived phylogenetic relationships among rhacophorid frogs have been in a state of flux since Liem (1970),

and continue to be under dispute. Grosjean et al. (2008) argued that foam nesting has evolved once in the Rhacophoridae. Construction of foam nest is found in the following genera of the Rhacophoridae: *Polypedates, Rhacophorus* and *Chiromantis*. The Asian species of *Chiromantis* that were assigned to the genus *Chirixalus* has been reported paraphyletic (Frost et al., 2006). Yu et al. (2009) after comparing six gene sequences, merged *Chirixalus vittatus* and *Chirixalus doriae* with the genus *Chiromantis* and also commented that *Chiromantis* and *Polypedates* are phylogenetically close.

Little information is available on the ecology of *Chiromantis simus*. It was described from Assam, India (Annandale, 1915) by a single holotype specimen (ZSI 17971) and there was no

information published for the next 84 years and was believed to be extinct from India (Daniels, 2005). The species was rediscovered on 8 October, 1998 from Assam, and on 8 September, 1999 from a marshland at Rajpur, West Bengal, 600 km from its type locality (Deuti et al., 2000). Deuti (2001) investigated its breeding ecology at Rajpur and found it to be restricted to the eastern edge of the marsh (22°42′45″N, 88°39′25″E). Due to developmental activities at Rajpur in 2001, after completion of Deuti's work, part of the eastern portion of the marshland was filled up for human habitation.

Observations were made at my residence cum natural garden, located at Rajpur, 150 m from Deuti's study site. The garden contains old Mango, Jack fruit and other large trees. I constructed a gradually sloping, saucer-shaped shallow cemented bird bath (surface area: 185 x 185 cm, maximum depth: 10 cm) in 2006 (22°42′36″N, 88°39′23″E). During the early-monsoon of 2006, *Polypedates leucomystax* constructed foam nests above the cemented pool (Banerjee and Deuti, 2006). In 2007, both *C. simus* and *P. leucomystax* made foam nests over the same pool. From 2008, I started studying the breeding ecology of *C. simus*. I kept daily records of number of frogs seen on the trees over the pool, number of frogs calling, number of foam-nests constructed, etc, for three breeding seasons, 2008, 2009 and 2010.

The main course of the river Ganga used to flow through Rajpur some 800 years before present, and after shifting her course, the died-up river basin became a mature alluvial plain (Chattopadhyay, 1999). The soil of Rajpur is therefore naturally fertile, and there were patches of dense vegetation in the area, up to the recent past, which is fast disappearing due to rapid urbanization. I have tried to collect information as much as possible on the ecology of this localized species if it gets extirpated from this locality.

Materials and Methods

The study period was from June 2008 to September 2010, and the study site was a shallow cemented pool as mentioned above. Saplings of different tree species were planted around the pool to study nesting site preferences of frogs. Photographs were taken with a Panasonic –Lumix FZ 50 camera and calls were taken from the video footage. The audio track was copied onto a Marantz PMD 660 recorder to make a digital sound file. Background noise was filtered out using background spectral subtraction in WavePad V4.03. Call figures were generated using Raven 1.3. Call analysis was done by Dale Roberts, University of Western Australia. Behaviour of the frogs on the canopy I studied by climbing on an 8 m high bamboo ladder. I fixed a 200 W lamp above the pool for illumination. I strewn different species of leaves found at Rajpur over the pool to study food preference of the tadpoles. Over-wintering of the tadpoles was studied by keeping the tadpoles in a glass aquarium. Daily rainfall was measured by a rain gauge. Data on average ambient temperature was collected from Alipore Meteorological Department, Kolkata, 15 km to the north.

Observations

Foam-nesting.– A total of 51, 49 and 102 nests were made in 2008, 2009 and 2010, respectively, with an average of 67 per year. Maximum number of foam nest was made in July in all the three years. Maximum number of foam nests made in a single night was 11 (on 1 August 2010; Table 1).

Nest building site.– No specificity was observed on the type of trees for making foam nests. Frogs nested on 13 different plant species and on three inanimate objects over the pool. The name of the plants are: *Artocarpus heterophyllus* (Jack fruit), *Syzygium jambos* (Golap Jam), *Euphoria longan* (Aansphal), *Strebulus asper* (Sheora), *Quisqualis indica* (Rangoon Creeper), *Murraya paniculata* (Kamini), *Epipremnum* sp (Money plant), *Ixora* sp (Rangan), *Litsea* sp. (Kukur Chite), *Barringtonia acutangula* (Hizal), *Euphorbia sp* (Cactus), *Polyalthia suberosa* and Wild Arum. The nests were constructed on big trees, small trees and climbers. They were seen to make nests on both dorsal and ventral sides of the leaves, even on both sides of the same leaf. Many nests were made on dry stick and on dead tree log kept over the pool and one was made on the side of the cemented wall. On 17 June 2008, interestingly, a fresh nest was made on a four-day old *P. leucomystax* nest.

Height of the nests.– Minimum height of nest was the underside of a Money Plant leaf, 2.5 cm

over the water surface. Maximum height of nest was 6 m on a tall Jack fruit tree. These frogs were regularly seen on the canopy of the tall Jack-fruit tree at a height of 6–9 m.

Proximity of the nests from the pool.– Most of the 202 foam-nests were constructed on vegetation directly over the water surface of the pool. However, 14 were made 5–60 cm outside from the margin of the cemented pool where emerging tadpoles are unlikely to drop into water at hatching.

Colour of the nests.– Newly made nests were white in colour. One-day old nests became off-white and after two days some nests changed to deep rufous in colour while some remained off-white as before. The rufous colour was water soluble. Those nests that got drenched in drizzle for a long time became white as before and the colour was seen to be removed in the falling water drops from the underside of the foam nest (Fig 10). I didn't find any example of deep rufous coloured foam nest in anurans during literature survey. Both monoandrous and polyandrous nests had brown colour, but when the female appears on the nest for the second time for 'polishing', the colour of the nest becomes brown. Probably the female secretes some biomolecule in 'reduced' state and that in contact with air becomes oxidised and becomes rufous in colour. To confirm it, I collected one polyandrous foam nest just after egg deposition and before polishing and found that it remained white in colour. I have seen that rufous nests are less attacked by dipteran maggots but this require further study.

Call.– The species was observed to be always sonorous and their common type of call was a loud metallic sound 'chirrric' which appear as short pulse trains in oscillogram (Fig. 13). The 'chirrric' call I consider as advertisement call and was made in three situations: (a) a single male called alone without any reply from other males, (b) two or more males communicated with each other from different corners of their habitat and from canopy to the lower shrubs i.e., non-overlapping and alternating type, and (c) after a long silent period many males suddenly called simultaneously in a chorus i.e., overlapping type. In West Bengal during the monsoon season rain does not fall everyday. Cool rainy stretches are followed by hot rainless stretches. During those rainless hot stretches frogs rarely called. Another type of call was

Table 1. Nesting calendar for *Chiromantis simus* at Rajpur, West Bengal.

Year	Nests made in each month					First nesting date	Last nesting date	Nesting period in days	Maximum number of nests made in single night	Maximum number of individuals seen above pool
	June	July	August	September	Total					
2008	8	17	17	9	51	16 June	25 September	100	6 (13 July)	14 (13 July)
2009	0	29	15	5	49	1 July	12 September	74	5 (9 July) and 5 (11 July)	10 (30 June)
2010	10	34	32	27	102	23 June	23 September	92	11 (1 August)	31 (27 June)

Table 2. Activity calendar for *Chiromantis simus* at Rajpur, West Bengal.

Year	Date of first rain shower	Date of last rain shower	First sighting of year	Last sighting of year	First advertisement call of year	First aggressive call of year	Last advertisement call of year
2008	commenced before study started	26 October	commenced before study started	3 October	commenced before study stated	commenced before study started	3 October
2009	3 May	16 November	3 May	25 October	25 May (cyclone 'Ayela' hit West Bengal on the day)	26 June	3 October
2010	16 February	-	17 February	27 September	22 May (cyclone 'Laila' hit West Bengal on the day)	22 June	27 September

Table 3. Foam nest making sequence in *Chiromantis simus* over a cemented water-pool at Rajpur, West Bengal, eastern India, on 16 September 2008.

Time	Description of activity
20.00	female with swollen abdomen moving slowly from one leaf to another on different trees over pool
20:28	female firmly grip underside of a Rangoon Creeper leaf and did not move from it
20:35	three males watching female
20:38	two of three males approach female
20:50	nearest male jump onto leaf and starts amplexus
20:51	pair sits without movement
(Start)	male start rubbing feet with each other; female also start rubbing feet with each other
20:52	commencement of foam production female rub feet vigorously; foam production continues 'kirikiri' call heard from distant males
21:02	increase in size of foam nest
21:04	increase in size of foam nest; female move hind limbs vigorously
21:06	second male approach amplecting pair; size of foam large
21:08	second male join mating pair second male on one side of female and first male on her dorsum
21:10	female occasionally move hind limbs; other males calling from distance
21:15	third male come nearer trio
21:17	commencement of rain
21:18	second male departs; third male approaches amplecting pair; egg mass irregular in shape and outer eggs uncovered and visible
21:21	first male departs heavy rains; female alone, moving hind limbs to shape nest
21:25	'kirikiri' call of males from distance
21:30	third male leaves leaf within 5 seconds of arrival
21:31	female sitting alone
21:35	female shape foam nest with hind limbs; dorsal side of feet used in shaping lower portion and ventral side of feet to shape side of nest; female often rubbing feet together to wipe or clean foam from feet
21:39-21:41 (Finish)	female leaves nest; eggs now covered and invisible by foamy outer layer; nest a regular rounded shape
Total = 52 min.	

also heard frequently when males were fighting among or moving towards the gravid female or during multiple amplexus. I describe this call as 'kirikirikirikiri'. The 'kirikiri' call may be an aggressive call. In oscillogram aggressive call appear as repeated note with each note formed by a short pulse train with much higher pulse rates than in the advertisement calls. Aggressive calls were often longer than advertisement calls. Dominant frequencies in both calls were about 3.3 kHz but rising about 0.2 kHz from the beginning to the end of calls (Dale Roberts, pers. comm.). On rainy or overcast days, males called the advertisement call throughout the day but the frequency and intensity of calling increased after dusk. Their vocal sac is of external, median and sub-gular type. During aggressive call their vocal sac was much less inflated than the advertisement call.

Diel activity pattern.– They became active at sunset and continued calling throughout the night. Maximum number of frogs over the pool was seen between 20:00 and 01:00 h of the following day (Fig. 12). Nests were constructed at night between 20:00 and 02:00 h of the following day though maximum number was made at around 1100h. During the day, adult frogs were sighted resting on dead branches of the Rangoon Creeper (*Quisqualis* sp.) or on leaves of *Strebulus* sp. or *Litsea* sp. or in the folds of dead *Ix-*

ora sp. leaf. By day they rested with their heads down and fore legs folded under throat. Dermal warts became more prominent at rest (Fig. 2). Tadpoles hid themselves in rotten leaves during the day time and occasionally come out momentarily to gulp air. At night they came out from hiding and moved freely. Tailed froglets generally came out from water about two hours after sunset. By next morning, their tail was almost completely absorbed. To facilitate photography, I had fixed a 200W electric bulb high above the pool. Sometimes, the bulb was kept on for the whole night and no noticeable behavioural change was observed between the dark nights and the lighted nights. This suggests that they were not much disturbed by increasing illumination.

Amplexus.– Biswas (2000) described amplexus of *C. dudhwaensis* as axillary. Over the pool some nests were constructed by a single pair and some by multiple male amplexus. The male *C. simus* was observed either holding the fore legs of the female by his opposable fingers (Fig. 3) or, in front of her fore legs beneath her throat. In almost all of my observations the female selected the leaf first and waited for some time and then the male/males jumped on her to initiate amplexus. Often the males fought among themselves and called loudly, producing the aggressive call. However, *Polypedates leucomystax* were always seen to have true axillary amplexus and away from the nest making leaf above the cemented pool and later on moved to the chosen leaf.

During multiple male amplexus, the *C. simus* males placed themselves around the female wherever they could get hold, even beneath the female under her abdomen. Up to seven males were seen during a multiple amplexus (Fig. 1). To the naked eye there was no size difference among the *C. simus* males in multiple amplexus. Jennions et al. (1992) also didn't find any size difference among the males during multiple amplexus in *Chiromantis xerampelina*- but there can be big differences in size of dorsal and ventral males in polyandrous mating in *Crinia georgiana* (Byrne and Roberts, 2004). I observed that the males choose females most of the time. It was observed that while a number of male is approaching towards a gravid female, another gravid female sitting on another leaf is

longing fruitlessly for male/males for an hour. In one occasion I saw acrobatic display of one male near an amplecting pair like a spring doll and in another occasion I saw an amplecting female is dislodging the other approaching males by kicking (video clip available from author).

Types of limb movement.– Limb movement observed in *C. simus* was different to that described by Biswas (2000) for *C. dudhwaensis*. In *C. simus* at the beginning of amplexus, the male started rubbing both his feet together very fast, possibly to stimulate the female. Subsequently the female also started rubbing both her feet together and then started producing foam and laying eggs (Fig. 4). After starting foam production, the male rarely moved his legs but the female went on moving her legs at regular intervals perhaps to cover the exposed eggs evenly by a foamy coat. The female used the dorsal side of her feet to shape the bottom surface of the nest (Fig. 5) and the ventral side of her feet to shape and wipe the sides of the nest (Fig. 6). Often the female rubbed both her feet together with each other, may be to clear foam from her feet. The webbing between toes may have some role in foam nest construction. I previously mentioned that *P. leucomystax* nested every year over this same pool. During nest making, their leg-movement pattern was seen to be totally different from that of *C. simus*. They were never seen to use their hind feet in shaping the nest as in *C. simus*. Instead, they were seen to 'churn' the foam by immersing the hind legs deep into a large foamy mass.

Sequence of foam nest preparation.– I studied the sequence of foam-nest construction on five occasions in 2008 and they took on an average 53 min (range 45–66 min) to complete the nest. I recorded on video all the steps associated with foam nest constructing on 16 September 2008. Details of amplexus are given sequentially in Table 3, which started at 20:50 h and ended at 21:41 h.

Repeat layering.– Dry, hot spells within the monsoon season (mentioned before) may last for a week or more and *C. simus* rarely made nest in that period. If that occurred, the female could not produce much foam and the egg mass remained uncovered and irregular in shape. After completion of the nest making the female reappeared at the nest (Fig. 7) and produced ad-
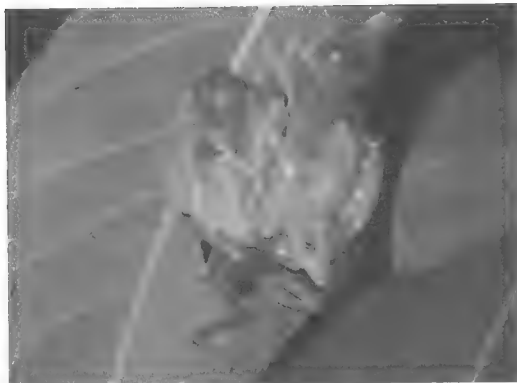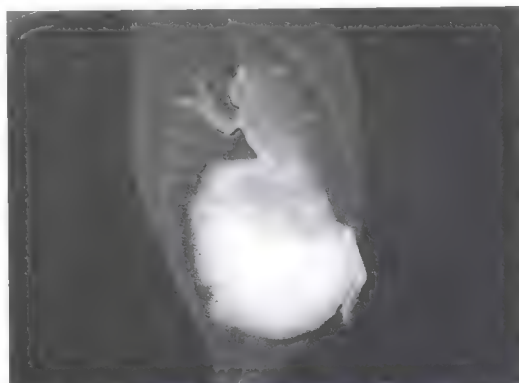
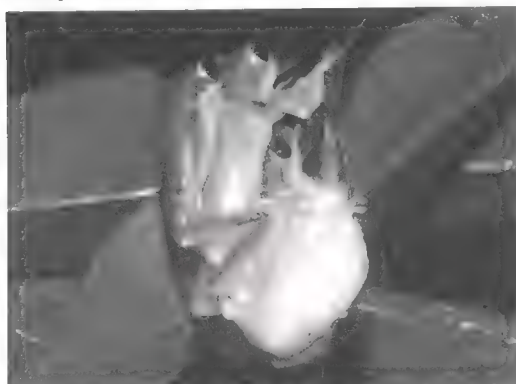**Figure 1.** Multiple amplexus by eight *Chiromantis simus.*

Figure 2. *Chiromantis simus* resting on a Sheora leaf by day, head down and fore limbs folded under throat. Note prominent tubercles on its body.

Figure 3. *Chiromantis simus* in axillary amplexus, with male holding fore limbs of female sitting on its dorsum and another under her abdomen.

Figure 4. Commencement of foam secretion in *Chiromantis simus*. Both male and female rub hind limbs with each other in rapid succession.

Figure 5. Female *Chiromantis simus* shaping nest using dorsal side of her hind limbs.

Figure 6. The last male *Chiromantis simus* leaving. The female is shaping nest using ventral side of her hind limbs.

ditional amount of foam to cover the eggs and 'polished' the nest continuously with her hind legs. During that process it was observed that the female went down to the water below and absorbed water through her skin, inflated her abdomen and again went up to the nest. After

that she slowly squeezed her inflated abdomen and distributed watery foam all over the nest with her hind legs until finally her abdomen was shrunk (Fig. 8). This alternate abdominal inflating-squeezing process went on repeatedly throughout the night (maximum number

Figure 7. After absorbing water, inflated female *Chiromantis simus* reappears at recently laid, irregular, egg mass which is uncovered.
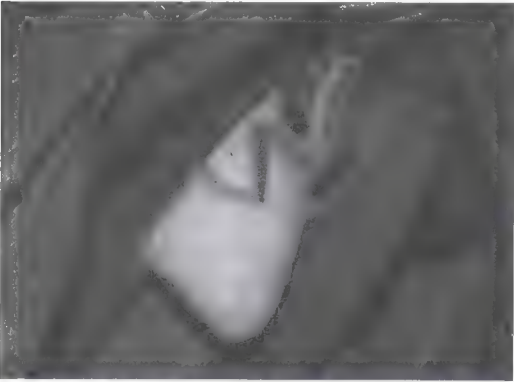
Figure 8. Female *Chiromantis simus* squeezing her abdominal muscles to produce watery foam to cover egg mass and distribute it evenly, using her hind limbs.

Figure 9. Giant Crab Spider (*Heteropoda* sp.) preying on adult *Chiromantis simus*.

Figure 10. Deep rufous coloured foam nest of *Chiromantis simus* with rufous coloured liquid dripping from bottom.
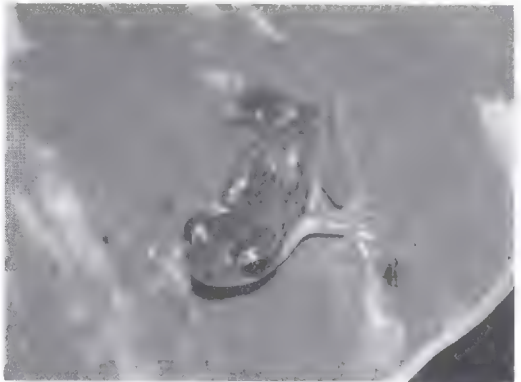
Figure 11. *Chiromantis simus* specimens with heavily spotting on their backs and limbs.

observed was four times). The process of absorbing water by *C. simus* was different from that of *P. leucomystax*. In the same pool female *P. leucomystax* were always seen to inflate by submerging their bodies under water. *C. simus* females absorbed water from the wet margins of the pool through the abdominal skin. Time distribution in these three steps were as follows: (a) water absorption through abdominal skin took about 45 min, (b) additional watery foam production and 'polishing' foam nest took about 22 min, and (c) time taken to go up and to get down took about 15 min.

Development of tadpoles.– The first *C. simus* tadpole metamorphosed into froglet was on 03 September, 30 July and 17 July in 2008, 2009 and 2010, respectively. About five tadpoles metamorphosed per night from the pool during the warm months and the maximum number was 15. The leaves of the dominant tree species available at Rajpur were regularly strewn into the pool to know their food preference. They preferred Jack fruit leaf *(Artocarpus heterophyllus)*. I succeeded in developing three batches of *C. simus* tadpoles into froglets, feeding only Jack fruit leaf in ± 45 days. A late monsoon nest, constructed on 21 September 2008, was kept separately in a glass aquarium and tadpole development was
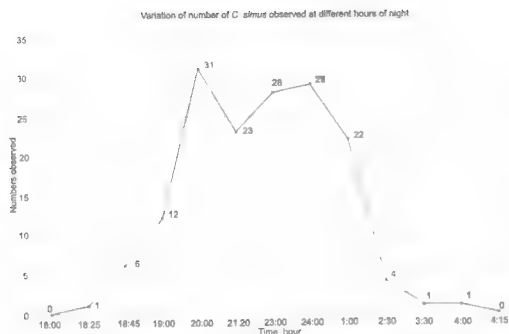
Figure 12. Variation in number of *Chiromantis simus* observed at different hours of night.
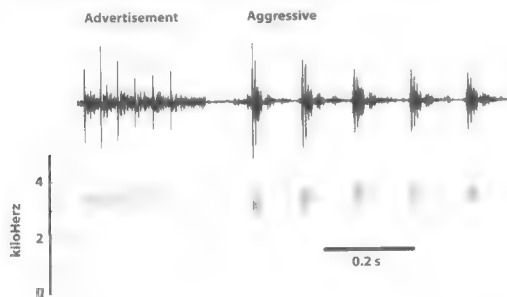

Figure 13. Upper trace oscillograms, lower trace sound spectrograms of advertisement and aggressive calls of *Chiromantis simus.*

studied throughout the winter season. The first tadpole metamorphosed on 19 November 2008 (in 59 days) and this first phase continued up to 27 November 2008. In the second phase, the rest of the tadpoles metamorphosed between 2–9 February 2009 (maximum 141 days) none in December or January (winter).

Activity calendar.– Nesting period was 87 days in average per year (Table 1). In 2009 nesting was started delayed because of delayed start of monsoon. First sighting of the year was on 03 May 2009 and 17 February 2010 respectively. The 2009 summer was abnormally hot reaching 42.1°C which was 6°C above normal; accompanied with a long rainless stretch of six months (26 October 2008 to 3 May 2009). On the contrary, first rain of the next year was on 16 February 2010 (Table 2).

First advertisement call was heard on 25 May 2009 and 22 May 2010, respectively, and both were cyclonic and rainy days. At the beginning of season they called less frequently which increased gradually with time. When nesting period is not started they were seen scattered far away from the pool but once nesting is started

they were seen mostly around the pool. First aggressive call was heard on 26 June 2009 and 22 June 2010, respectively, almost one month after advertisement call (Table 2). The first nesting was observed within five and one days of first aggressive call, i.e., on 1 July 2009 and 23 June 2010, respectively (Table 1 and 2). Nesting was started with the onset of monsoon.

In 2008, 2009 and 2010 from the middle of September, the frequency of calling gradually decreased. The calling duration was observed about four months in the previous three years (Table 2).

The other foam nesting tree frog utilized the same pool for breeding was *Polypedates leucomystax* which started foam nesting on 16 May 2009 and 1 May 2010, respectively. Unlike them the *C. simus* behaved as a true monsoon breeder, not a pre-monsoon (or 'Nor-Wester') breeder. It bred throughout the entire span of monsoon from the start to the end.

Nesting ended early in 2009 because of an infestation of a hairy caterpillar in the first week of September on Rangoon Creeper plant over the pool. The same hairy caterpillar also infested the same creeper in 2010 in the same period and I removed them manually, so they nested 11 days more (Table 1).

Predation and Conservation.– The Giant Crab Spider (*Heteropoda* sp.) is locally common and was observed sucking on *C. simus* adults above the cemented pool numerous times (Fig. 9). Aquatic beetles (Dytiscidae) were seen to consume tadpoles of *C. simus* voraciously and dipteran fly maggots were seen to attack foam nest of the said species.

During the last three years, *C simus* bred successfully in a small saucer shaped shallow cemented water pool. Although stagnant water pools are perceived locally as promoting the breeding activities of mosquitoes, only rarely were mosquito larvae found in this pool. Over time, this pool developed into an ecosystem supporting many different groups of aquatic carnivorous insects, and presumably those kept the mosquito population under control. Perhaps *ex-situ* breeding of *C. simus* can be conducted in such conditions, if needed.

Discussion

Biswas (2000) described 4-6 week breeding period for *Chiromantis dudhwaensis at Dehradun*, Uttar Pradesh and Deuti (2001) mentioned a four-week breeding period for *C. simus* at Rajpur, West Bengal. In my study, the extended breeding period of *C. simus* for 87 days from June to September over the cemented pool might be due to maintaining constant water depth throughout the rainy season. Biswas (2000) reported that *C. dudhwaensis* formed foam-nests on *Ipomea carnea* while Deuti (2001) reported that *C. simus* nested on *Saccharum spontaneum* grass and Deuti and Dutta (2002) reported that *C. vittatus* nested on grassy marshland only. I found *C. simus* nesting on 13 plant species and three inanimate objects that surrounded the cemented pool. The canopy-dwelling habit of *C. simus* I observed has not been reported previously. In India, little information on canopy-dwelling amphibians is available except for *Philautus nerostogona,* which lives 20 m high on trees (Biju and Bossuyt, 2005).

Fourteen of 202 foam-nests that I observed were constructed on vegetation, 5–60 cm from the margin of the water in the cemented pool. This may be because the frogs could not determine the water margin precisely. Byrne and Whiting (2008) also reported occasional foam-nesting by *Chiromantis xerampelina* on vegetation at the water's edge, where water was not present underneath the nest. Jennions et al. (1992) noted that amplexus in *C. xerampelina* took place 0.3–2.0 m from the nesting site. Biswas (2000) also mentioned that in *Chiromantis dudhwaensis,* amplexus occurred away from the nesting leaf and later the pair moved on. In *C. simus*, I found that the time interval between start of amplexus and start of foam-production was short and within that period the amplecting pair could not move a long distance.

Multiple amplexus has not been reported previously in *C. simus,* although it was reported in *C. dudhwaensis* (Biswas, 2000). Simultaneous polyandry has been documented in a wide range of taxonomically diverse group of organisms but its benefit is currently one of the most compelling, but least understood questions in evolutionary biology (Simmons, 2005).

Simultaneous polyandry is reported in at least 13 species from five families of frogs. In some species it increases fertilization efficiency (Byrne and Whiting, 2008). In several species of frogs that build foam nests of the families Rhacophoridae and Leptodactylidae, males involved in multiple male spawning do not physically compete to grasp females. Instead, males systematically position themselves around foam nests and show muscle convolutions that are associated with sperm release. In these frogs, it seems highly probable that simultaneous polyandry might increase fertilization efficiency (Kusano et al., 1991).

On the contrary in some species simultaneous polyandry is reported to decrease fertilization efficiency. Female *Crinia georgina* (Myobatrachidae) incurs significant reductions in fertilization success when they mate with multiple males (Byrne and Whiting, 2008). The most probable explanation for this relationship is that competing males interfere with egg laying or ability of rival males to assume optimal mating positions.

At Rajpur, whether polyandry increases or decreases fertilization efficiency is yet to be determined. Most of the time males were seen to make peaceful co-existence during foam nesting but occasionally they were seen to engage in fighting. Their agonistic or aggressive 'kirikiri' call was heard from almost all the multiple amplexus.

This study reports on the following behavioral observations for the first time in *C. simus* and records each observation by using still and video photography and call recording. These observations are (a) their canopy dwelling and canopy nesting habit, (b) their diel activity pattern, (c) their different types of call pattern and their visualization, (d) choosing an unusual breeding habitat (cemented pool) and utilizing it totally, (e) their wide nesting site preference on different plants and even inanimate objects, (f) extended breeding period, (g) male combat, male acrobatics male choosing female but in rare case female kicking towards males, (h) amplexus pattern and multiple amplexus, (i) nest making duration and description of each step, (j) leg movements during nest making, (k) reappearance of female at foam nest and repeated layering of watery foam throughout the night, (l) change of colour of foam nests, (m) predator of adults, tadpoles and foam nest, (n) overwin-

tering of tadpoles and (o) tadpoles preference of Jackfruit Leaf as natural food.

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A new karst dwelling *Cyrtodactylus* (Squamata: Gekkonidae) from Son La Province, north-western Vietnam

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(with 11 text-figures)

ABSTRACT.- A new karst dwelling species, *Cyrtodactylus bichnganae* sp. nov. from an isolated karst forest, separated from the Pu Luong – Cuc Phuong Karst Forest Complex, located on the western side of the Da River, Son La Province, north-western Vietnam, is differentiated from all other species of *Cyrtodactylus* by a SVL of 95.3–99.9 mm; 10–12 superlabials; 9–11 infralabials; 16–18 irregular tubercles rows at midbody; 30–31 scales rows between ventrolateral folds at midbody; 28 femoral and precloacal pores separated by diastema on each side; NST_4 of 16–20, and slightly enlarged transverse subcaudal scales; presence of a dark nuchal loop; six or seven dark brown dorsal bands and eight dark rings on the tail.

KEY WORDS.- Gekkonidae, *Cyrtodactylus bichnganae*, new species, taxomony, north-western Vietnam.

Introduction

The genus *Cyrtodactylus* in Vietnam contains at least 18 species (Smith, 1921; Darevsky and Szczerbak, 1997; Ziegler et al., 2002; Ngo and Grismer, 2006; Nguyen et al., 2006; Heidrich, et al., 2007; Hoang et al., 2007; Orlov et al., 2007; Nazarov et al., 2008; Ngo, 2008; Ngo and Bauer, 2008; Ngo et al., 2008; Rösler et al., 2008; Geissler et al., 2009).

Field surveys focused on gekkonid throughout Vietnam and its offshore Islands have resulted in the reconfirmation of *Cyrtodactylus intermedius* (Smith, 1917) in Vietnam and the recent descriptions of 14 new species (Ngo and Grismer, 2006, Grismer and Ngo, 2007; Ngo, 2008; Ngo and Bauer, 2008; Ngo et al., 2008; Rösler et al., 2008; Ngo and Ziegler, 2009; Ngo et al., 2009; Ngo and Gamble, 2010; Grismer et al., 2010). A survey on 8 May 2009 in the isolated karst forest near Son La Town, Son La Province, that is separated from the Pu Luong –

Cuc Phuong Karst Forest Complex, resulted in another new species of *Cyrtodactylus* associated with karst formations that can not be ascribed to any known species and is described herein.

Materials and Methods

Locality data were taken using a Garmin™ III GPS. Photographs of living specimens were taken with a LINUX digital camera DMC–FZ30. Specimens were euthanised with MS–22, liver tissue samples removed, fixed with 10% formalin, and transferred in 60–70% ethanol and deposited in the Zoological Collection of Faculty of Biology, University of Natural Sciences (UNS) in Ho Chi Minh City, Vietnam.

The measurements follow Bauer (2003) and Grismer (2005) and were taken with calipers (to the nearest 0.1 mm): snout–vent length (SVL: from tip of snout to vent), trunk length (TrunkL: from posterior edge of forelimb insertion to anterior edge of hind limb insertion),

forearm length (ForeaL: from base of palm to elbow), crus length (CrusL: from base of heel to knee); tail length (TL: from vent to tip of tail), tail width (TW: measured at widest point of tail); head length (HeadL: distance between retroarticular process of jaw and tip of snout), head width (HeadW: maximum width of head), head height (HeadH: maximum height of head, from occiput to underside of jaws), ear length (EarL: longest dimension of ear); orbital diameter (OrbD: greatest diameter of orbit), nares to eye distance (NarEye: distance between anterior corner of eyelid and posterior corner of nostril), snout to eye distance (SnEye: distance between anterior corner of eyelid and tip of snout), eye to ear distance (EyeEar: distance from anterior edge of ear opening to posterior corner of eyelid), internarial distance (Internar: distance between nares), and interorbital distance (Interorb: shortest distance between left and right supraciliary scale rows).

Scale counts and external observations of morphology follow Bauer (2003) and Grismer (2005) and were done using an Olympus SZ60 binocular microscope: supralabials (SupL: counted the scales from behind the rostral to the corner of mouth); infralabials (Infra: counted the scales from behind the mental to the corner of mouth); ventral scales (VenS: counted across the belly between the ventrolateral folds at midbody); frontal scales (FronS: number of scales in a straight line between anterior corners of orbits); tubercle rows (TubR: number of dorsal longitudinal rows of tubercles at midbody between the lateral folds); paravertebral tubercles (Paravert: paravertebral tubercles counted in a single row from the middle level of the forelimb insertions to the middle level of the hind limb insertions); number of subdigital lamellae beneath fingers I–V (NSFI–NSFV); number of subdigital lamellae beneath toes I–V (NSTI–NSTV); orbit–nostril scales (Orb–nosS: number scales in a straight line from the anterior edge of orbit to the posterior edge of nostril); intersupranasal scales (IntersupS: number of small scales in broad contact with the supranasals); enlarged lateral chinshields (Enlar–chin: number of enlarged lateral chinshields in contact with first postmental); enlarged femoral scales (EnlfemS: number of enlarged femoral scales beneath each thigh) and postanal tubercles (PAT: number

of tubercles on each side of postanal region). Sex was determined based on the presence or absence of hemipeneal swellings and well-developed femoral and precloacal pores. Measurements and scale counts were made on the right side, unless stated otherwise.

Comparisons were made based on examination of material in the Zoological Collection of University of Natural Sciences, Ho Chi Minh City, Vietnam, as well as data from published descriptions and illustrations provided in broader faunal and taxonomic treatments (e.g., Smith, 1935; Taylor, 1963; Brown and Parker, 1973; Szczerbak and Golubev, 1986; Hikida, 1990; Ulber and Grossmann, 1991; Ulber, 1993; Darevsky and Szczerbak, 1997; Das, 1997; Das and Lim, 2000; Ziegler et al., 2002; Bauer, 2002 and 2003; Bauer et al., 2002, 2003; 2009; Günther and Rösler, 2003; Das et al., 2004; David et al., 2004; Pauwels et al., 2004; Grismer, 2005; Grismer and Leong, 2005; Grismer et al., 2007, 2008; Kraus and Allison, 2006; Kraus, 2007, 2008; Nguyen et al., 2006; Youmans and Grismer, 2006; Heidrich et al., 2007; Hoang et al., 2007; Orlov et al., 2007; Hayden et al., 2008; Linken et al., 2008; Nazarov et al., 2008; Ngo, 2008; Ngo and Bauer, 2008; Ngo et al., 2008; Rösler and Glaw, 2008; Rösler et al., 2008; Geissler et al., 2009; Paul et al., 2009; Lei and Hui, 2010).

Systematics
Cyrtodactylus bichnganae sp. nov.
(Figs. 1–10)

Holotype.– UNS 0473, an adult male collected by Ngo Van Tri in karst forest near Son La Town, Son La province, northwestern Vietnam (21°21'N 103°54'E) on 8 May 2009, ca. 600 m in elevation.

Paratype.– The paratype UNS 0474, same data as holotype.

Diagnosis.– *Cyrtodactylus bichnganae* sp. nov. differs from all congeners by the following combination of characters: SVL 95.3–99.9 mm; body, limbs and digits long, slender; original tail long (TL/SVL 1.16); presence of nuchal loop; dorsal pattern consisting of six or seven dark bands on a brown background; nine white rings on tail; pore-bearing precloacal and femoral scales separated; 10 pore-bearing precloa-

cal scales in males separated from nine pore-bearing femoral scales on each side by two poreless scales; 18–19 interorbital scales across the frontal bone; 18–19 scales between eye and nostril; 30–31 rows of ventral scales between ventrolateral folds; 16–18 irregular longitudinal rows of smooth conical tubercles at midbody between lateral folds; 26–27 paravertebral tubercles; 16–20 subdigital lamellae on first toe; 21–22 subdigital lamellae on the fourth toe; no tubercles on tail; subcaudal scales transversely enlarged.

Description of holotype.– Adult male, SVL: 95.3 mm; head moderately long (HeadL/ SVL: 0.27), relatively narrow (HeadW/HeadL: 0.68), depressed (HeadH/HeadL: 0.37), distinct from neck; loreal and interorbital region convex, canthus rostralis region relatively flat, but nostrils sunken posteriorly; frontonasal region concave; snout elongate (SnEye/HeadL: 0.40), pointed and longer than orbital diameter (OrbD/SnEye: 0.61); scales on snout and forehead small, rounded, granular, homogeneous; scales on snout larger than those on occipital region; eye large (OrbD/HeadL: 0.25); pupil red, crenellated when closed and rounded when maximally opened; supraciliaries short, bearing tiny conical spines posteriorly; ear opening oval, oblique, small (EarL/HeadL: 0.08); eye to ear distance greater than diameter of orbital (EyeEar/OrbD: 1.17); rostral incompletely divided by an inverse Y-shaped, shallow, dorsal groove; two enlarged supranasals in contact anteriorly, separated by an intersupranasal posteriorly (Fig. 3); rostral in contact with first supralabial on each side, nostril, and supranasals; nostril oval, surrounded by supranasal, rostral, first supralabial, and three enlarged postnasals; 2 or 3 rows of small scales separating orbit from supralabials; mental triangular, wider (4.1 mm)

Figure 1. Male holotype UNS 0473 of *Cyrtodactylus bichnganae* sp. nov. in life.

Figure 2. Female paratype UNS 0474 of *Cyrtodactylus bichnganae* sp. nov. in life.

Figure 3. Rostral scales of the holotype of *Cyrtodactylus bichnganae* sp. nov.

than high (2.3 mm); one pair of enlarged postmentals in broad contact medially, bordered by mental anteriorly, first infralabial laterally, fol-
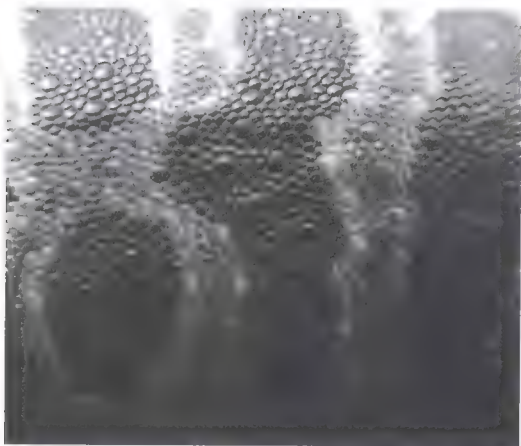
Figure 4. Dorsal tubercles of the holotype of *Cyrtodactylus bichnganae* sp. nov.
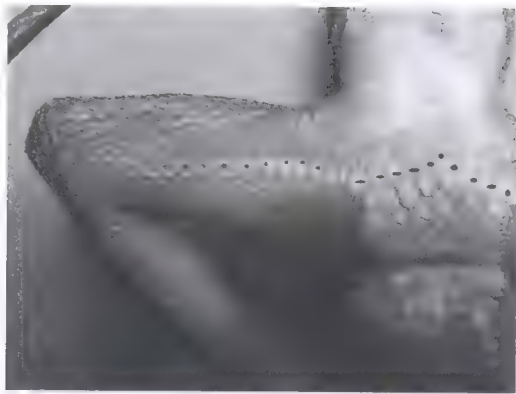

Figure 7. Precloacal and femoral pores of the holotype of *Cyrtodactylus bichnganae* sp. nov. with blue spot marking present, 10 small precloacal pores disconnected with 9 femoral pores in each side.
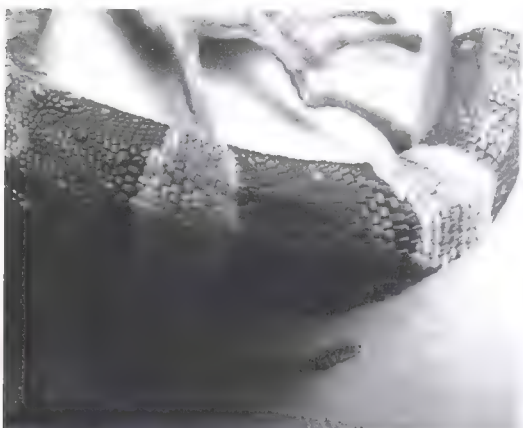

Figure 5. Caudal dorsum of *Cyrtodactylus bichnganae* sp. nov. without tubercles;

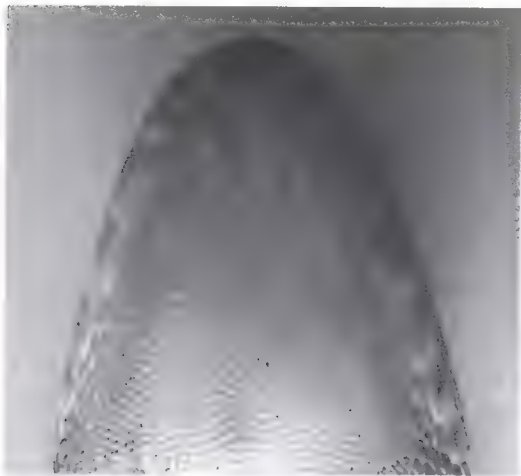**Figure 8.** Right fingers of holotype of *Cyrtodactylus bichnganae* sp. nov.

Figure 6. Mental scales of the holotype of *Cyrtodactylus bichnganae* sp. nov. with two enlarged postmentals posteriorly.
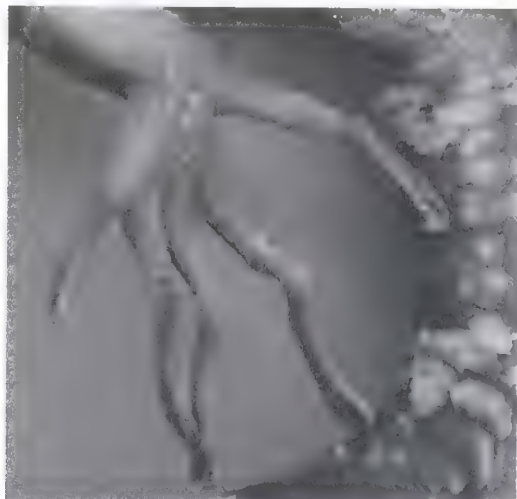

Figure 9. Right toes and enlarged subcaudal scales of holotype of *Cyrtodactylus bichnganae* sp. nov.

Figure 10. Comparison of sizes between male holotype and female paratype of *Cyrtodactylus bichnganae* sp. nov.

Figure 11. Karst forest, macrohabitat of *Cyrtodactylus bichnganae* sp. nov. in Son La Province, Vietnam.

bercles; ventral scales larger than dorsum, smooth, relatively round, subimbricate, largest on posterior part of the belly, in 30 rows across mid-belly between ventrolateral folds; gular region with relatively homogeneous, smooth scales; no precloacal groove; 36 smooth enlarged precloacal scales, 10 of which bear pores in an angular series, and in contact with 12 enlarged femoral scales on each side, nine of which bearing pores (Fig. 7); scales on palm smooth; hind limbs scales granular with scattered, smooth tubercles; tubercles on hind limbs smaller than those on dorsum, decreasing in size on dorsal surface of manus and pes.

Fore- and hind limbs moderately slender (ForeL/SVL: 0.15; CrusL/SVL: 0.19); digits moderately robust, strongly inflected at basal interphalangeal joints, all bearing slightly curved claws; basal subdigital lamellae nearly as broad as digit and narrow lamellae distal to digital inflection, excluding ventral claw sheath, lacking a scansorial surface on manus: 8–8–8–8–8 subdigital lamellae on manus; 10–9–8–8–8 subdigital lamellae on pes; narrow lamellae distal to digital inflection and excluding ventral claw sheath: 8–8–9–10–10 subdigital lamellae on manus; 11–10–9–8–8 subdigital lamellae on pes; one row of small, non lamellar granules between basal and distal lamellar series; interdigital webbing present but weakly developed. Relative length of digits in mm: (manus) IV (10.0) > III (8.9) > II (8.4) >V (8.0) > I (5.3); (pes): I (10.7) > II (10.4) > III (9.1) > IV (7.2) >V (5.5).

Tail regenerated, 94.2 mm in length, slender, tail tip tapering to a point; longer than snout vent length (TailL/SVL: 1.01); two whitish

lowed by four enlarged chinshields (Fig. 6); 10 (R), 11(L) supralabials to the eye angle, eighth below the midorbital position of eye; 10 (R) 9 (L) infralabials; 19 interorbital scales; 18 scales between eye and nostril.

Body slender, elongate (TrunkL/SVL: 0.41) bearing weak ventrolateral folds; dorsal scales granular to weakly conical; tubercles conical, 3–4 times larger than the size of adjoining scales, regularly distributed from occipital region to base of tail, in 16 rows at midbody between ventral lateral folds (Fig. 4), those on flanks and in occipital region smallest; 27 paravertebral tu-

Table 1. Mensural and meristic data for the type series of *Cyrtodactylus bichnganae* sp. nov. Abbreviations as in materials and methods, all measurements in mm. F: female, M: male, Reg: regenerated tail.

	Holotype UNS 0473	Paratype UNS 0474	Range		Holotype UNS 0473	Paratype UNS 0474	Range
Sex	M	F	n = 2	Paravert	27	26	26–27
SVL	95.3	99.9	95.3–99.9	VenS	30	31	30–31
HeadL	25.6	24.5	24.5–25.6	Pre–pores	10	8 pitted	10
HeadW	17.3	16.9	16.9–17.3	Fempores	9+9	1 +1 pitted	9+9
HeadH	9.5	8.2	8.2–9.5	EnlfemS	12/11	13/13	11–13
EarL	2.1	2.3	2.1–2.3	PAT	2/2	2/1	1–2
OrbD	6.3	6.1	6.1–6.3	IntersupS	1	1	1
NarEye	7.3	7.1	7.1–7.3		I: 8+8	I: 9+9	16–18
SnEye	10.3	9.8	9.8–10.3		II: 8+8	II: 8+10	16–18
EyeEar	7.4	6.8	6.8–7.4	NSF	III: 8+9	III: 7+12	17–19
InterNar	2.6	2.4	2.4–2.6		IV: 8+10	IV: 8+12	18–20
InterOrb	6.8	7.6	6.8–7.6		V: 8+10	V: 9+10	18–19
TrunkL	39.3	39.9	39.3–39.9		I: 10+11	I: 10+12	21–22
BW	12.8	15.5	12.8–15.5		II: 9+10	II: 10+11	19–21
ForeaL	14.2	14.3	14.2–14.3	NST	III: 8+9	III: 8+9	17
CrusL	18.0	17.7	17.7–18.0		IV: 8+8	IV: 8+12	16–20
TL	96.3 (Reg)	115.6	96.3–115.6		V: 8+8	V: 7+9	15
TW	8.5	7.0	7.0–8.5	FronS	19	18	18–19
SupL	10/11	11/12	10–12	Orb–nosS	18	19	18–19
Infra	10/9	11/10	9–11	Enlar–chin	4	4	4
TubR	16	18	16–18				

postcloacal tubercles on each side. Original portion segmented by 9 or 10 rows of scales and lacking tubercles except for the basal-most segment having six parasagittal rows of enlarged, weakly keeled tubercles continuous with those of the dorsum and reducing to four at the plane of autotomy (Fig. 5); subcaudals smooth, juxtaposed, transversely enlarged, extending length of tail (Fig. 9); scales on dorsal tail flat, smooth, hexagonal.

Colouration in life (Fig. 1).– Head yellowish brown with dark spots on occiput; dark nuchal loop; eyes red; seven dark narrow dorsal bands between limb insertions, one anterior to forelimbs; original tail whitish bearing seven dark brown rings, regenerated portion of tail reddish brown bearing scattered small whitish spots; limbs pinkish white with scattered yellowish and dark blotches on dorsal surfaces; pinkish white on below.

Variation.– HeadL/SVL: 0.25; HeadW/HeadL: 0.69; HeadH/HeadL: 0.33; SnEye/HeadL: 0.40; OrbD/SnEye: 0.62; OrbD/HeadL: 0.25; EarL/HeadL: 0.09; EyeEar/OrbD: 1.11; TrunkL/SVL: 0.40; ForeL/SVL: 0.14; CrusL/SVL: 0.18 and

TailL/SVL: 1.16. Colour variation is shown on Fig. 10. Differences in scalation are shown in Table 1. Females are usually larger than males (99.9 mm vs. 95.3 mm SVL); male colouration (Fig. 1) is often brighter (Fig. 2).

Etymology.– The specific epithet honours senior author's daughter, Ngo Hoang Bich Ngan, because he was not at home on her fifth birthday, when he collected the type series. We suggest the English name, Bich Ngan's Bent-toed Gecko, and the Vietnamese name, "Thằn lằn chân ngón Bích Ngân".

Distribution and Natural History.– *Cyrtodactylus bichnganae* sp. nov. is currently known only from the karst forest surrounding Son La Town. Most of the karst forest in this region has been degraded over a long period of time by settlements and agricultural activities, hence the vegetation is secondary forest even though some of the terrain reaches 800–1000 m asl (Fig. 11). The karst formations within the forest compose a vast series of numerous dry caves and deep caves with water. *Cyrtodactylus bichnganae* sp. nov. was observed and collected in the crevices of karst formations, often living in male-female

Table 2. Comparison of *Cyrtodactylus bichnganae* sp. nov. with other congeneric species bearing precloacal and femoral pores separated by diastema in Indochinese peninsula. Database for comparison cited from Bauer et al. (2009); Nazarov et al. (2008); Ngo & Bauer (2008); Rösler et al. (2007); Ziegler et al. (2002).

	C. bichnganae sp. nov.	*C. brevipalmatus*	*C. caovansungi*	*C. consobrinus*	*C. erythrops*	*C. huynhi*	*C. interdigitalis*	*C. phongnhakebangensis*	*C. pulchellus*	*C. takouensis*	*C. tigroides*	*C. ziegleri*
n	2	1	2	2	1	7	1	8	2	6	1	8
SVL	95.3–99.9	72.0	90.4–94.0	125.0	78.4	54.8–79.8	80.0	85.0–96.3	115	74.7–81.1	83.22	84.6–93.0
TailL	96.3–115.6	80.0	93.0–120.0	62.0	–	29.1–78.6	?	100.5–106.7	–	43.7–91.0	109.3	95.0–107
VenS	30–31	40–44	40–43	24–30	28	43–46	37–42	32–42	33–35	39–40	34	33–39
TubR	16–18	18	16–18	18–20	18–20	16–18	18–22	11–20	?	18–20	13	20–24
Pre-pores	10	7–10	9	9–11	9	7–9	14		8	3–4	8–9	5–8
Femoral pores in both sides	18	6–7	6	0–6	19	3–8	8–9	32–42	14–18	0–2	10–14	0–6
Subcaudal scales	enlarged	enlarged	enlarged	enlarged	enlarged	not forming a single median row of transversely enlarged	enlarged	enlarged	enlarged	median enlarged	enlarged	uniform granular
SupL	10–11	12–14	10	10–16	7(L)	–	12–14	9–13	–	10–11 (n = 4)	12	9–12
InfraL	10–11	10–11	9	9–13	8	–	10–12	8–12	–	10–13 (n = 4)	10	7–10
NST4	16–20	16–20	22	22–28	20	17–21	17–22	18–26	19–20	18–20	19–23	18–21
Tubercles on lateral skin folds	absent	present	present	present	absent	present	absent	absent	absent	absent	absent	?
Body pattern	6–7 bands	no band	4 dark brown bands with rough edges	narrow bands	spots, blotches, bands	dark bands cream to yellow	spots	4 broad bands	bands	4–5 bands	bands	4–6 irregular bands
Tail pattern	rings	bands	bands	bands	bands	9–10 bands	?	bands	bands	three bands	10 bands	bands

pairs. Females would emerge onto the karst sur-
face at night 6–7 m from their crevice retreats.
Other gecko observed in the same habitat is
Gekko gecko.

Comparison with Other Species

Cyrtodactylus bichnganae sp. nov. differs from
C. batucolus Grismer, Onn, Grismer, Wood Jr.
and Belabut, 2008; *C. chanhomae* Bauer, Su-
monthai and Pauwels, 2003; *C. consobrinoi-
des* Annandale, 1905; *C. deveti* (Brongersma,
1948); *C. epiroticus* Kraus, 2008; *C. feae* (Bou-
lenger, 1893); *C. fumosus* (Müller, 1895); *C.
jarujini* Ulber, 1993; *C. klugei* Kraus, 2008; *C.
loriae* (Boulenger, 1898); *C. macrotubercula-
tus* Grismer and Ahmad, 2008; *C. marmoratus*
Gray, 1831; *C. novaeguineae* (Schlegel, 1837);
C. phongnhakebangensis Ziegler, Rösler, Her-
rmann and Vu, 2002; *C. robustus* Kraus, 2008;
C. serratus Kraus, 2007; *C. tiomanensis* Das
and Lim, 2000; *C. tripartitus* Kraus, 2008; *C.
seribuatensis* Youmans and Grismer, 2006; *C.
variegatus* (Blyth, 1859); and *C. zugi* Oliver,
Edgar, Mumpuni, Iskandar and Lilley, 2009, by
the presence of 1–2 poreless scales separating
the precloacal and femoral pores.

Cyrtodactylus bichnganae sp. nov. dif-
fers from *C. badenensis* Nguyen, Orlov and
Darevsky, 2006; *C. darmandvillei* (Weber,
1890); *C. eisenmanae* Ngo, 2008; *C. grismeri*
Ngo, 2008; *C. jarakensis* Grismer, Onn, Gris-
mer, Wood Jr. and Belabut, 2008; *C. jellesmae*
(Boulenger, 1897); *C. laevigatus* (Darevsky,
1964); *C. semenanjungensis* Grismer and Le-
ong, 2005; *C. sermowaiensis* (De Rooij, 1915);
C. thirakhupti Pauwels, Bauer, Sumontha and
Chanhome, 2004; and *C. wallacei* Hayden,
Brown, Gillespie, Setiadi, Linkem, Iskandar,
Umilaela, Brickford, Riyanto, Mumpuni and
McGuire, 2006, by having precloacal pores as
opposed to their absence.

Cyrtodactylus bichnganae sp. nov. differs
from *C. adleri* Das, 1997; *C. angularis* (Smith,
1921); *C. annulatus* (Taylor, 1915); *C. auren-
sis* Grismer, 2005; *C. ayeyarwadyensis* Bauer,
2003; *C. brevidactylus* Bauer, 2002; *C. cattie-
nensis* Geissler, Nazarov, Orlov, Böhme, Phung,
Nguyen and Ziegler, 2009; *C. cavernicolus* (In-
ger and King, 1961); *C. chauquangensis* Hoang,
Orlov, Ananjeva, Johns, Hoang and Dau, 2007;
C. chrysopylos Bauer, 2003; *C. condorensis*

(Smith, 1921); *C. cracens* Batuwita and Bahir,
2005; *C. cryptus* Heidrich, Rösler, Vu, Böhme
and Ziegler, 2007; *C. edwardtaylori* Batuwita
and Bahir, 2005; *C. elok* Dring, 1979; *C. frae-
natus* (Günther, 1864); *C. gansi* Bauer, 2003; *C.
hontreensis* Ngo, Grismer and Grismer, 2008;
C. ingeri Hikida, 1990; *C. intermedius* (Smith,
1917); *C. irianjayaensis* Rösler, 2000; *C. ir-
regularis* (Smith, 1921); *C. khasiensis* (Jerdon,
1870); *C. lateralis* (Werner, 1896); *C. malaya-
nus* (De Rooij, 1915); *C. malcolmsmithi* (Con-
stable, 1949); *C. matsuii* Hikida, 1990; *C. ni-
griocularis* Nguyen, Orlov and Darevsky, 2006;
C. oldhami (Theobald, 1876); *C. pantiensis*
Grismer, Onn, Grismer, Wood Jr. and Belabut,
2008; *C. papilionoides* Ulber and Grossmann,
1991; *C. papuensis* (Brongersma, 1934); *C.
paradoxus* (Darevsky and Szczerbak, 1997);
C. peguensis (Boulenger, 1893); *C. philippini-
cus* (Steindachner, 1867); *C. pseudoquadrivir-
gatus* Rösler, Vu, Nguyen, Ngo and Ziegler,
2008; *C. pubisulcus* Inger, 1957; *C. quadrivir-
gatus* Taylor, 1962; *C. ramboda* Batuwita and
Bahir, 2005; *C. rubidus* (Blyth, 1860); *C. soba*
Batuwita and Bahir, 2005; *C. spinosus* Linkem,
McGuire, Hayden, Iqbal, Setiadi, Bickford and
Brown, 2008; *C. stresemanni* Rösler and Glaw,
2008; *C. subsolanus* Batuwita and Bahir, 2005;
C. sumonthai Bauer, Pauwels and Chanhome,
2002; *C. sworderi* (Smith, 1925); *C. wakeorum*
Bauer, 2003; *C. yoshii* Hikida, 1990; *C. zhao-
ermii* Lei and Hui, 2010; and *Cyrtodactylus* sp.
(Ngo, Grismer and Grismer *submitted*) in hav-
ing femoral pores as opposed to lacking them
in males.

Cyrtodactylus bichnganae sp. nov. differs
from *C. agamensis* (Bleeker, 1860) by larger
size (95.3–99.9 mm vs. 49.7mm), lower num-
ber of ventral scales (30–31 vs. 67) and subdigi-
tal lamellae on fourth toe (16–20 vs. 26), and
tubercles on the lateral skin folds (absent as
opposed to present); from *C. buchardi* David,
Teynie and Ohler, 2004, it differs by its larger
size (95.3–99.9 mm vs. 33.4mm), presence (as
opposed to absence) of a nuchal loop; presence
of enlarged femoral scales (as opposed to their
absence); presence of subcaudal scales (as op-
posed to smaller, round subcaudals); a banded
(as opposed to a blotched) body pattern; lower
number of ventral scales (30–31 vs. 38); from
C. derongo Brown and Parker, 1973, it is dif-

ferentiated by its by smaller size (95.3–99.9 mm vs. 112mm); lower number of ventral scales (30–31 vs. 46–48); fewer subdigital lamellae on the fourth toe (16–20 vs. 24–26); moderately enlarged subcaudal scales as opposed to small subcaudals and the absence of tubercles on the lateral skin folds (as opposed to their presence); from *C. murua* Kraus and Allison, 2006, it differs by its smaller SVL (95.3–99.9 mm vs. 113mm), body patterns (6–7 bands vs. 3 bands), number of longitudinal rows of dorsal tubercles (16–18 vs. 20–22), presence of tubercles on the lateral skin folds (as opposed to their absence); lack of dorsal caudal tubercles as opposed to their presence, fewer subdigital lamellae on the fourth toe (16–20 vs. 24–25), and having enlarged, as opposed to smaller and rounded subcaudal scales.

Among *Cyrtodactylus* species having discontinuous series of precloacal and femoral pores, *C. bichnganae* sp. nov. differs from *C. biordinis* Brown and McCoy, 1980; *C. capreoloides* Rösler, Richards and Günther, 2007; *C. louisianensis* (De Vis, 1892); *C. mimikanus* (Boulenger, 1914); *C. russelli* (Bauer, 2003); *C. sadleiri* Wells and Wellington, 1985; *C. salomonensis* Rösler, Richards and Günther, 2007, by lower number of pores in males; and from *Cyrtodactylus aaroni* Günther and Rösler, 2003; *C. aequalis* Bauer, 2003; *C. agusanensis* (Taylor, 1915); *C. annandalei* Bauer, 2003; *C. baluensis* Mocquard, 1890; *C. brevipalmatus* (Smith, 1923); *C. caovansungi* Orlov, Nguyen, Nazarov, Ananjeva and Nguyen, 2007; *C. consobrinus* Malkmus, 1989; *C. gubernatoris* (Annandale, 1913); *C. huynhi* Ngo and Bauer, 2008; *C. interdigitalis* Ulber 1993; *C. pulchellus* Gray, 1828; *C. redimiculus* King, 1962; *C. slowinskii* Bauer, 2002; *C. takouensis* Ngo and Bauer, 2008; *C. tigroides* Bauer, Sumonthai and Pauwels, 2003; *C. tuberculatus* (Lucas and Frost, 1900); *C. wetariensis* (Dunn, 1927) and *C. ziegleri* Nazarov, Orlov, Nguyen and Ho, 2008, in having a higher number of pores in males (see Rösler, Richards and Günther, 2007).

Cyrtodactylus bichnganae sp. nov. has a similar banding pattern and dorsal tuberculation to *Cyrtodactylus phongnhakebangensis* Ziegler, Rösler, Herrmann and Vu, 2002; *C. cryptus* Heidrich, Rösler, Vu, Böhme and Ziegler, 2007 and *C. chauquangensis* Hoang, Orlov, Ananje-va, Johns, Hoang and Dau, 2007. However, the number of bands of *C. bichnganae* sp. nov. is greater (6–7 vs. 4–5 in all latter species). The arrangement of the precloacal-femoral pores of C. *bichnganae* sp. nov. resembles that of *C. phongnhakebangensis*, except that the number of pores is less (28 versus 32 42) and they are discontinuous (Table 2). It differs from *C. phongnhakebangensis*, *C. cryptus* and *C. chauquangensis* in lacking tubercles on tail (present in *Cyrtodactylus bichnganae* sp. nov.).

Discussion

Four other species of *Cyrtodactylus* associated with karst forest in Vietnam are *C. chauquangensis* Hoang, Orlov, Ananjeva, Johns, Hoang and Dau, 2007, from Nghe An Province, north-central Vietnam; *C. cryptus* Heidrich, Rösler, Vu, Böhme and Ziegler, 2007; *C. phongnhak-enbangensis* Ziegler, Rösler, Herrmann and Vu, 2002 both from Quang Binh Province, Central Vietnam; and *C. paradoxus* (Darevsky and Szczerbak, 1997) from Kien Giang Province, southwestern Vietnam. The discovery of *Cyrtodactylus bichnganae* sp. nov. represents the fifth karst dwelling *Cyrtodactylus* and it is, thus far, known only from the western bank of the Da River.

Longstanding settlements and agricultural areas have severely degraded the general area of the karst forest. Moreover, most of the caves are continually visited and disturbed by local people which has led to the degradation of the microhabitat of *Cyrtodactylus bichnganae* sp. nov. For this reason, it is believed that this population is in serious threat and may be declining being difficult to find. Additional field surveys are planned to try to locate other areas (at least within the isolated karst forest in Son La Province) where this species may occur.

Ackowledgements

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Augmentation of intracellular antioxidant enzyme activities during hibernation in *Duttaphrynus melanostictus* (Schneider, 1799)

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(with three text-figures)

ABSTRACT.– We investigated the activity of antioxidant enzymes in the heart and liver tissue during the hibernating period in the Indian toad, *Duttaphrynus melanostictus* (Schneider, 1799), collected from mud holes of selected sites in Midnapur (22°15'N, 87°39'E) during mid January (air temperature 7.4–10.2°C) when hibernation peaks. Reduced glutathione (GSH) level was significantly low during the period of hibernation in hibernating individuals in comparison to non-hibernating ones. On the other hand, catalase and superoxide dismutase activity showed a significant increase ($p < 0.05$) during the period of hibernation, in comparison to non-hibernating condition. Increased regulation of antioxidant enzymes during the period of hibernation appears to be an indicator of enhanced oxidative stress. These studies are of basic importance in understanding the hibernating physiology of *D. melanostictus*.

KEYWORDS.– Hibernation, catalase, superoxide dismutase, reduced glutathione.

Introduction

Oxygen is essential for most life forms, but it is also inherently toxic due to its biotransformation into reactive oxygen species (ROS). In fact, the development of many animals and plant pathological conditions, as well as natural ageing, is associated with excessive reactive oxygen species produced and/or of a decreased antioxidant activity. However, a number of animal species are able to tolerate, under natural conditions, situations with large potential for oxidative stress. In many animals, cellular oxidative stress resistance is associated with enhanced expression of intracellular antioxidant enzymes. For example, intracellular antioxidant enzymes may exhibit an up regulation during hibernation and therefore, during that period, it can protect tissues against oxidative stress (Page and Peters, 2009). A molecule of catalase can convert million molecules of hydrogen peroxide to water and oxygen per second. All animals use catalase in every organ, with a particularly high concentration of this enzyme in the liver (Goodsell, 2004). The optimum pH for catalase activity is approximately 7, though it varies across the species. Another important antioxidant enzyme is superoxide dismutase (SOD), which catalyzes the dismutation of superoxide into oxygen and hydrogen peroxide. As such, it confers an important antioxidant defense nearly in all cells exposed to oxygen. Glutathione (GSH) is the major thiol-disulfide redox buffer in cells and is a critical component of antioxidant defense. In the intestine of squirrels, the total pool of GSH equivalents has found to be lowest while undergoing arousal and highest during the inter-bout arousals. During hibernation, the activity of intestinal GSSG reductase may be reduced by approximately 50%, but had no effect on the activities of glutathione peroxidase or on the other hand, activities of glucose-6-phosphate dehydrogenase (G6PD) do not change (Carey et al., 2003).

Current literature indicate that preparation for natural hibernation in ground squirrels include an elevation of antioxidant enzymes (superoxide dismutase, glutathione peroxidase), some proteins (metallothionein) and some metabolite (ascorbate) antioxidants in order to deal with a surge of reactive oxygen species during the arousal when rates of oxygen consumption rise very rapidly (Storey, 2004). During aestivation, catalase activity drops by 31% during 24 h of anoxia and superoxide dismutase (SOD) activity decreases by 43% during the 15 days of aestivation in the European snail, *Biomphalaria tenagophila* (Ferreira and Alencastro, 2003). This is consistent with the overall decrease in metabolic rate during aestivation or anoxia. Indeed, the heart-beat diminished by 28–36% during aestivation. In toads, the activity of many enzymes, particularly the glutathione linked enzymes, were significantly lower in the tissues of aestivating individuals than in active ones. In addition, antioxidant enzymes are largely insensitive to high urea, which accumulates during aestivation (Grundy and Storey, 1998). Freezing resulted in a significant rise in the activity of the muscle and lung catalase (183% and 63%, respectively) and in the muscle glutathione peroxide (52%) in garter snakes. Increasing amount of antioxidant capacity is of great relevance for species such as garter snakes and wood frogs (Hermes-Lima and Zenteno-Savin, 2002). Anoxia enhanced muscle and liver SOD activity by 59% and 118% (Hermes and Storey, 1993). Experiments indicated that the switch of temperature from normal room temperature to 20^0C in *Rana ridibunda* also affected the activity of antioxidant enzymes; catalase in the kidney and muscle rose 33% and 126%, respectively, whereas SOD increased 2–4 folds in the liver and 2.5 fold in muscle. G6PD activity was also affected in some organs (Bagnyukova and Storey, 2003). In contrast, no differences in SOD expression either at protein level or activity were found between active and hibernating squirrels. But the activity of catalase which catalyses an alternative hydrogen peroxide detoxification pathway was higher in the heart and brain of torpid squirrel, but lower in the liver (Page and Peters, 2009). Evidence of oxidative stresses associated with hibernation has been detected

in many organs. In the torpor stage, the intestine of the ground squirrels shows several signs of oxidative stress including elevated level of conjugated dienes (product of lipid peroxidation) and decrease in reduced glutathione (Storey and Storey, 2004).

However, few studies have been performed to elucidate the free radical metabolism during the hibernation period. In the present study we investigated the antioxidant enzymes during hibernation in key organs of the common Indian toad, *Duttaphrynus melanostictus*. This toad is common in West Bengal, in eastern India, and is abundant during summer, is found hibernating in mud holes and inside human habitations during the winter.

Materials and Methods

Study animals.– Ten adult common Indian toads (*Duttaphrynus melanostictus*), each weighing 80–100 g, were collected from mud holes in Midnapur (22°15˝N, 87°39˝E), West Bengal State, eastern India, during mid-January (air temperature 7.4–10.2°C), when hibernation was in its peak. A non-hibernating group from the site in the month of June (air temperature 35–40°C) formed the control.

Euthanasia.– Hibernating and non-hibernating individuals were euthanised by pithing. Tissue samples (heart and liver) were collected immediately thereafter. Animal handling was approved by ethical guideline laid down by the Committee for the Purpose of Control and Supervision of Experimental Animals (CPCSEA), constituted by the Animal Welfare Division, Government of India on the use of animals in scientific research.

Estimation of superoxide dismutase activity.– Superoxide dismutase activity was estimated at room temperature using the procedure of Mishra and Fridovich (1972). Ten micro litres of tissue homogenate were added to 970µl (0.05M, PH 10.2, 0.1mM EDTA) of sodium carbonate buffer. Twenty micro liter of 30mM epinephrine (dissolved in 0.05% acetic acid) were added to the mixture to start reaction. Superoxide dismutase activity was measured at 480nm for 4 min on a Hitachi U-2000 spectrophotometer. Activity was expressed as the amount of enzyme that inhibits the oxidation of epinephrine by 50%.
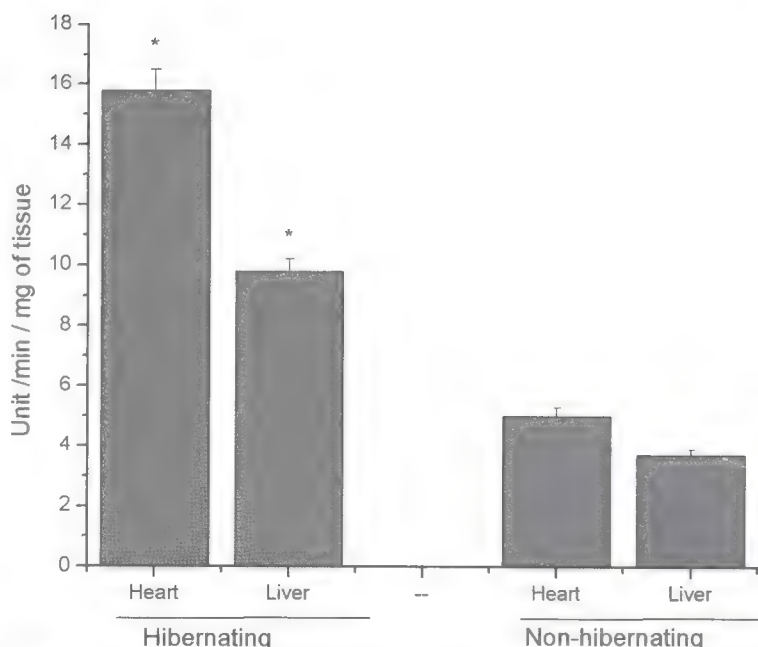
Estimation of catalase activity.– Catalase activity was determined following the method of Aebi (1984), with few modification at room temparature. Ten micro liters of ethanol were added to100 μl of tissue homogenate. The tissue mixture was then placed in an ice bath for 30 min and tubes were brought at room temperature, followed by the addition of 10μl of Triton X-100 RS. Ten μl of the tissue homogenate was added to a cuvette containing 240 μl (0.05 M, pH 10.2, 0.1Mm EDTA) of sodium phosphate buffer, and 250ml of
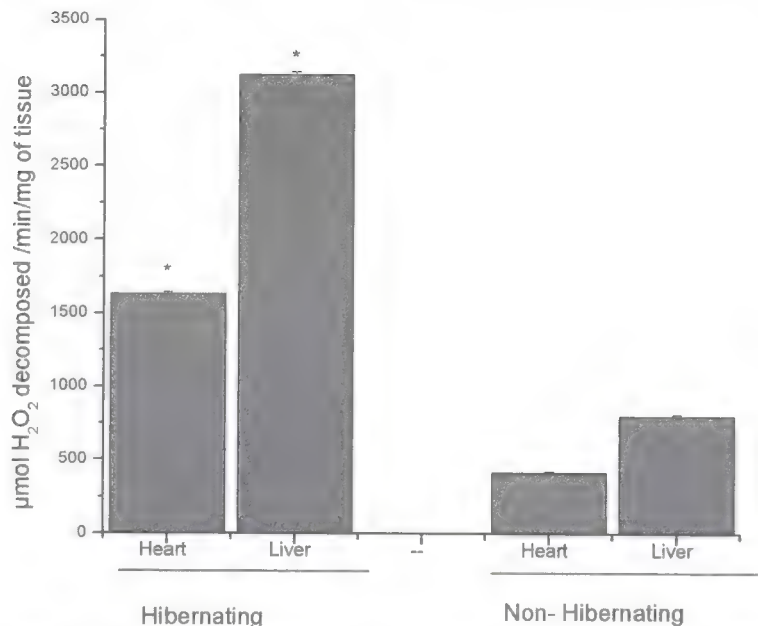

Figure 1. Comparison of total SOD activity in heart and liver tissue in hibernating and non-hibernating *Duttaphrynus melanostictus*. At the 0.05 level, the two means are significantly different (* $p < 0.05$).

66 mM H_2O_2 (dissolved in sodium phosphate buffer) was added to start the reaction. Catalase activity was measured at 240nm for 1 min using a Hitachi U-2000 Spectrophotometer. The molar extinction coefficient of 43.6 M "-1"cm^{-1} was used to determine catalase activity.

Estimation of reduced glutathione.– Reduced glutathione was estimated by the method of Griffith (1980). The required amount of tissue homogenate was mixed with 12% sulfosalicylic acid and centrifuged at 2000 x g for 15 min to settle the precipitated proteins. .1ml of protein free supernatant, .7ml of .3mM NADPH .1ml of 6mM DTNB and .48 unit of glutathione reductase were combined and absorbance of 5-thio 2- nitrobenzoic acid (TNB) was read at 412 nm. A standard curve was obtained with standard reduced glutathione.

Statistical analysis.– Statistical analysis was performed using Microcal Origin 6.0. Each biochemical experiment was performed at least three times, with five toads in each experimental group. Student's t-test was performed to compare the means, with a level of significance of $p < 0.05$.

Results

It was found that the SOD and catalase activity differ significantly in hibernating individuals compared to non-hibernating toads (Figs. 1–2). Reduced glutathione (GSH) was significantly low (t-test, $t = 14.93$; $p < 0.05$) during the hibernating period, in comparison with the non-hibernating phase, as shown in Fig. 3. From the present study, it was clear that the catalase activity of heart and liver is effectively increased ($t = 250$; $p < 0.05$) in hibernating individuals (1633 μmol H_2O_2/min/mg of tissue and 3124 μmol H_2O_2/min/mg of tissue), in comparison to the non-hibernating ones (413μmol H_2O_2/min/mg of tissue and 801μmol H_2O_2/min/mg of tissue). In the heart and liver tissue, superoxide dismutase activity was also significantly ($t = 37.84$; $p < 0.05$) increased in hibernating individuals (15.8 unit/min/mg of tissue and 9.8 unit/min/mg of tissue), compared to non-hibernating ones (5 unit/min/mg of tissue and 4.2 unit/min/mg of tissue).

Discussion

SOD and catalase activity differed in the heart and liver tissues between hibernating and non-hibernating toads. The total superoxide dis-

Figure 2. Comparison of catalase activity in heart and liver tissue in hibernating and non-hibernating *Duttaphrynus melanostictus* (asterisks indicate p < 0.05 in a t-test; see text for more information).
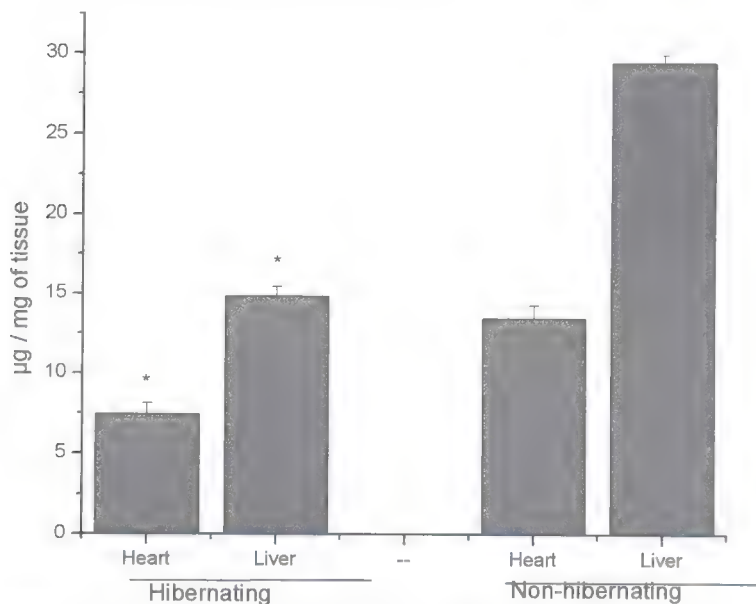
Figure 3. Comparison of reduced glutathione activity in heart and liver tissue in hibernating and non-hibernating *Duttaphrynus melanostictus* (asterisks indicate p < 0.05 in a t-test; see text for more information)

urea, which accumulate during aestivation (Grundy and Storey, 1998).

During hibernation, tissues such as liver and heart show a significant increase in the antioxidant enzyme pool to resist the excess ROS load. Reduced glutathione level during hibernation was the indicator of oxidative stress during this period. At that time, superoxide catalyzes the dismutation of superoxide to oxygen and less damaging and local acting hydrogen peroxide and subsequently catalase decompose the hydrogen peroxide to water and oxygen. A report also indicates that in the liver, the catalase and superoxide dismutase activities are increased by 33%, and a four-fold increase in *Rana ridibunda* exposed to a temperature of 20°C (Bagnyukova and Storey, 2003). It is concluded that hibernation is associated with enhanced oxidative stress resistance due to upregulation of intracellular antioxidant enzymes in the heart and liver tissue.

mutase and catalase activities changed significantly from July to October, during aestivation in *Apostichopus japonicus* (Wang and Yang, 2008). In aestivating toad antioxidant, the enzyme activities were largely insensitive to high

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Is the enigmatic blind-snake *Cathetorhinus melanocephalus* (Serpentes: Typhlopidae) an extinct endemic species from Mauritius?

In 1844, Duméril & Bibron (1834–54) described as *Cathethorinus melanocephalus* a new genus and species of blind-snake collected at an unknown locality by Péron and Lesueur. No further specimens have ever been found, and the form's taxonomic uniqueness has been confirmed in a recent study by Wallach and Pauwels (2008). François Péron was a zoologist on Baudin's 1801–1803 scientific expedition (e.g., Ly-Tio-Fane, 2003; Brown, 2000); Charles-Alexandre Lesueur was his assistant and also expedition artist. The expedition travelled via Tenerife to Mauritius, on to Australia and Timor and back to Mauritius before returning to France in early 1804 via South Africa. Somewhere on this itinerary, they collected the specimen of *Cathetorhinus*, the only blind-snake they brought back from their travels (Duméril and Bibron, 1834–1854; Duméril and Duméril, 1851). Most of their specimens carry locality labels, and although a few of these are notoriously wrong[1], they were conscientious collectors and the majority of their material is correctly assigned. Some, and *Cathetorhinus* is an example, lack any collection data, and this has fuelled much speculation over the years as to where the specimen came from. Wallach and Pauwels (2008) summarised the history of the specimen and commented that "the provenance of this species remains unknown: it is certainly Old World, and may be from (in order of probability) Timor, Australia, Mauritius or Tenerife"; it is registered in the Paris collection as MNHN 0138, adult, sex unknown. Until recently (see below), as Wallach and Pauwels pointed out, there was in the public domain "no mention of a small blind-snake or lizard comparable to *Cathetorhinus* in the records of the Baudin expedition or Péron

... so it appears that the Museum is responsible for attributing *Cathetorhinus* to the Baudin expedition." However there is much in the unpublished Péron and Lesueur manuscripts that is not reported in descriptions of the expedition (see Cheke, 2010, for material relevant to Mauritius), so this apparent negative evidence is not very persuasive - and is indeed false.

While researching the ecological history of Mauritius, I had occasion to consult (via copies sent to me by Gabrielle Baglione) the Lesueur archives held in the natural history museum in Le Havre, France. Although on this island they mostly kept to areas within easy reach of the capital Port Louis (Cheke, 2010), they additionally made an excursion in late 1803 (Boullanger, 1803) into the interior via the estate of an upland planter Toussaint de Chazal. He lived in the area now known as Mondrain, on a plateau adjacent to the Tamarin Gorge (see maps in Pineo, 1988:101 and Ly-Tio-Fane, 2003:xxx). In manuscript notes on the island's fauna (MS 15037; see Cheke, in press), Lesueur wrote the following in 1803 (my translation; original French in Appendix 1):

"No snakes exist on the island, but they are found on a neighbouring island that bears the name Ile aux Serpents[2] - it is a remarkable thing that in two places so close to each other, given that there is only ... [*blank in the text*], there are these reptiles on one and they are totally missing on the other. A very small species 4–5 inches maximum and thickness in proportion is, however, an exception. It is the only one found during our stay, on Mr Chazal's land near Grand Bassin. It was found amongst stones while clearing some land; it was about 8 inches below the soil surface. I note it here because it is a phenomenon to have seen a species that is new and the only one found belonging to the island."

The discovery location is somewhat equivocal, since Chazal's land was, by Mauritian standards, nowhere near Grand Bassin, a crater lake in then virgin forest some 9 km south of

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1. Notably the now extinct monotypic endemic Mauritian boa *Bolyeria multicarinata* (Serpentes: Bolyeriidae), labelled as from 'Nouvelle Hollande', i.e., Australia (e.g., Cheke and Hume, 2008).

2. Ile aux Serpents is a misnomer, as it is small, steep, covered in seabirds, almost vegetation-free and lacks snakes - however at the time snakes were to be found on adjacent Round Island, Flat Island and Gunners Quoin, all islets off the north coast of Mauritius (Cheke and Hume, 2008).

Mondrain, although the party proceeded to the lake from Chazal's house. Either way, in an upland locality in what was then uncleared forest, they (or possibly Chazal) found what seems to be a blind-snake given its very small size and the underground situation where it was found. In discussing this observation in a broader context, I (Cheke and Hume, 2008) considered it was probably an early record of the flowerpot snake *Ramphotyphlops braminus*, but this was before I had established that Péron and Lesueur had collected only the single blind-snake specimen on their entire expedition. The first formal attestation of *R. braminus* for Mauritius dates from 1869 (Cheke and Hume, 2008), 66 years after their visit.

Around 1900 Paul Carié, re-excavating the well-known fossil site, the Mare aux Songes in Mauritius, collected, *inter alia*, a few vertebrae 'from the middle region of the trunk' belonging to a Typhlopid snake. These were described by Hoffstetter (1946) as a new species *Typhlops cariei,* with the following general remarks (my translation):

"belongs indisputably to the genus *Typhlops* [*as then understood - ASC*], but it is noticeably larger than *T. braminus* (Daudin) [=*Rhamphotyphlops braminus*], the only species known in the current Mascarene fauna, to which it has perhaps been introduced. The fossil is also clearly distinguished from this latter species by various vertebral characters."

Hoffstetter apparently only compared the vertebrae to *R. braminus* and a single fossil species, *T. grivensis,* from the Miocene in France, but remarked that "current distribution indicates that medium or large sized species [of blind-snake] always, in the islands that shelter them, show endemic characteristics" – hence, he described his Mauritian subfossils as a new species.

Given that Mauritius once harboured an endemic typhlopid, that Péron and Lesueur found one there, and that they brought home only one blind-snake, it seems logical to infer that the animal from de Chazal's estate is one and the same as the enigmatic *Cathetorhinus* specimen in Paris. Against this, Lesueur described the length of his find as 4–5 French inches (109–136 mm), firmly in the normal range of adult *R. braminus* (around 120 mm in Mauritius, Cole, 2009; average of 1,286 specimens worldwide 128

mm, Wallach, 2009), while the *Cathetorhinus* specimen (Wallach and Pauwels, 2008) actually measures 178 mm (= 6.6 French inches). This is a bit larger than the maximum 170mm usually allowed for *braminus* (e.g., Daniel, 2002; Branch, 1988), though Glaw and Vences (1994) reported 175mm and Wallach (2009) commented that a very small number reach 190+ mm, up to 203 mm. However, Lesueur appeared to be writing from memory without the specimen actually before him, so, impressed by its small size, he may have exaggerated how tiny his snake actually was.

Proving a connection between *Cathetorhinus* and *'Typhlops' cariei* is not likely to be easy. Bones from the Mare aux Songes have very poor DNA preservation (e.g., Shapiro et al., 2002; Rijsdijk et al., 2009), and a specimen preserved in alcohol for 200 years is equally unlikely to be productive of DNA sequences. Although examining its central vertebrae should establish the relationship with *cariei* (or not), given that the specimen is both unique and a type, permission to dissect is unlikely to be given. Wallach (in litt.) was not permitted to examine its gut, and extracting a vertebra would be more damaging, but the necessary detail could be imaged using synchrotron microtomography (e.g. Betz et al., 2006; Tafforeau et al., 2006). However, it may not be possible to identify typhlopids with certainty to species level using vertebrae alone, so gut contents could also be used to establish its original locality, if endemic or other characteristic fauna, pollen or parasites were to be found. Hence, given the importance of establishing the provenance of this specimen, and also of establishing what would be yet another endemic genus for the isolated island fauna of Mauritius, I would urge the Paris authorities to permit internal examination of this specimen. Meanwhile, I have alerted the Mauritian Wildlife Foundation and researchers at the University of Mauritius to look out for any unusual blind-snakes in case *'cariei'* survives unseen, though in recent years only *R. braminus* and *Typhlops porrectus* have been recorded (Cole, 2009 and in litt.). The latter was first reported quite recently (Lever, 2003; Cheke and Hume, 2008), the first specimen being found on the lagoon islet of Ile Mangénie in 1993 (Carl Jones in litt.). It must have been present for some time to have reached off-

shore islets (Cheke and Hume, 2008), but Cole's
claim (2009) that it arrived "in the 1800s", is
without physical evidence (Cole in litt.), how-
ever plausible. It should be noted that at the
time of Péron and Lesueur's passage, potential
blind-snake predators, such as tenrecs, *Tenrec
ecaudatus* and house-shrews, *Suncus murinus*
had only been introduced relatively recently, al-
though rats, *Rattus* spp. had been there for much
longer (Cheke and Hume, 2008). Since then the
omnivorous Indian mongoose, *Herpestes auro-
punctatus* has been added to the fauna (ibid.)
- so the endemic blind-snake's chances of con-
tinued survival, despite its cryptic lifestyle, are
not good, although the discovery, in 1973, of a
previously unreported small semi-fossorial for-
est skink, *Gongylomorphus fontenayi* (Cheke
and Hume, 2008:168) is perhaps an optimistic
precedent.

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Appendix 1

Original French text of Lesueur's remarks on Mauritian snakes

The original French text of Lesueur's remarks on Mauritian snakes reads (his non-standard orthography): "Les ophidiens n'éxistent point sur l'isle mais ils se rencontrent sur une île très voisine qui porte le nom de l'Ile aux serpens - c'est une chose très remarquable que sur deux points si voisin lun de l'autre pourqu'il n'y a que … [*a blank in the text*] il y ait de ces reptiles sur l'un & qu'ils manquent tout a fait dans l'autre. Une très petite espèce de 4 a 5 p [= pouces] au plus & grosse en proportion fait cepend exception. C'est la seule qui fut trouvée pendans notre sejour, sur l'habitation de Mr Chazal près du grand bassin on le decouvrit [en] dans des pierres en défrichant un terrain [*sic*]; elle étoit a 8 [pouces] environ endessous du sol. Je l'indique ici parceque c'est un phénomène que [*sic*] d'en avoir vu une espèce qui est nouvelle & la seule l'on ait rencontrée appartenant à l'île.»

First occurrence of Spargana (Cestoda: Diphyllobothriidae) in the snakes, *Cryptelytrops insularis* (Viperidae) and *Dendrelaphis inornatus timorensis* (Colubridae) from Timor-Leste

(with two text-figures)

A survey of amphibians and reptiles in Timor-Leste (Kaiser et al., 2010), a recently independent country in the Lesser Sunda Archipelago, confirmed the presence of the white-lipped island pitviper, *Cryptelytrops insularis* (Kramer, 1977) and the Timor bronzeback, *Dendrelaphis inornatus timorensis* (Smith, 1927). We here report on the presence of cestode larvae in these species, their first record for Timor-Leste.

One *Cryptelytrops insularis* (hand-collected at ca. 5 km S Mehara, Lautém District, Timor-Leste, 08°30'S, 125°35'E, 28 July 2009) and one *Dendrelaphis inornatus timorensis* (hand-collected at the Timor Village Hotel, Wailakurini, Viqueque District, Timor-Leste, 08°47'S, 126°59'E, 22 July 2009), were examined. The snakes were euthanized by intracardial injection of a 5% procaine solution (Altig, 1980). In the process of preparing the specimens for preservation in 10% buffered formalin, several areas of subcutaneous swelling were noticed along the lateral sides of the body in both snakes. Careful incisions into the interscalar space above each swelling allowed extraction of elongate cream-colored 'worms' from subcutaneous tissue (Fig. 1). Each specimen was preserved in ethanol, regressively stained with haematoxylin, and mounted in balsam. Specimens were studied as whole-mounts under a dissecting microscope and identified as spargana (Fig. 2). Voucher specimens were deposited in the United States National Parasite Collection (USNPC, Beltsville, Maryland) as *C. insularis* (USNPC 102540) and *D. inornatus timorensis* (USNPC 102541).

Diesing (1854) proposed the term "sparganum" for larval cestodes with unknown affinity to adults. This designation is commonly used when referring to plerocercoid (= infective) larvae of tapeworms in the family Diphyllobothri-

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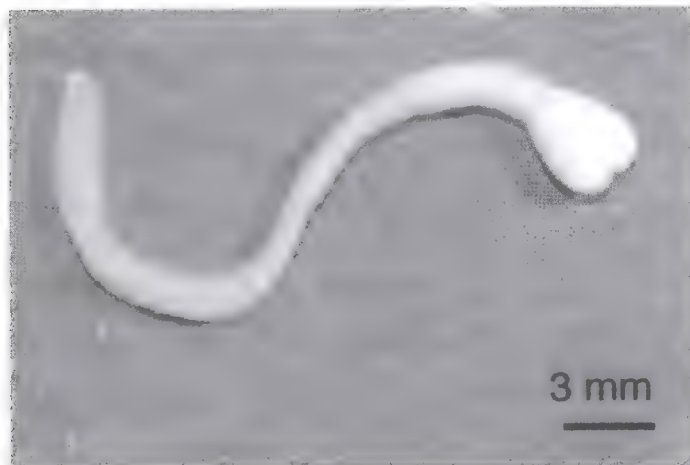**Figure 1.** Removal of a sparganum from *Dendrelaphis inornatus timorensis*. Photo by Paul Freed.

3 mm

Figure 2. Whole mount of a sparganum from *Dendrelaphis inornatus timorensis*. Photomicrograph by Charles R. Bursey.

The localities where we collected the infected snakes are typical frog habitats for Timor-Leste. The pitviper locality is adjacent to Lake Ira Lalaro, the largest freshwater body in Timor-Leste, whereas the bronzeback locality was in a riverine habitat. We observed rice paddy frogs of the genus *Fejervarya* and treefrogs of the genus *Polypedates* in both habitats and therefore consider it highly likely that the food chain for both *C. insularis* and *D. i. timorensis* includes both types of frogs as prey. Species of *Fejervarya* are known hosts for spargana elsewhere (e.g., Taiwan: Ooi et al., 2000), even to the exclusion of other frogs.

A case of human sparganosis reported by Munckhof et al. (1994) is instructive in illustrating how the spargana life cycle may be continued in a human host after its presence in one or more paratenic hosts. The infected individual was a Timorese refugee who had fled his homeland during the time of the Indonesian occupation (1975–99). As a result of the ceaseless persecution of people opposed to the occupation (Niner, 2009), he had only been able to survive during his escape by consuming both raw snakes and frogs. Thus, the connection between frogs, snakes, and humans was made at least once in Timor-Leste. We believe it is likely that during the food shortages in the decades of Indonesian occupation, sparganosis may have contributed considerably to the morbidity in the country but remained unnoticed in remote areas. There have only been four reported cases of human sparganosis in Indonesia (Margono et al., 2007), with one case occurring in Ambon, an island in the Moluccas archipelago. Timor-Leste is a new locality record for spargana, and

dae, and larvae of this type have been listed as parasites of reptiles from various regions of Eurasia (Table 1). Spargana are known from all vertebrate groups, except fish (Bray et al., 1994). In their life cycle, the first intermediate host is a freshwater copepod (Li, 1929), which provides opportunity for infection of amphibians. Infection of snakes can then easily occur by ingestion of amphibians carrying plerocercoids. No further larval development occurs in the snake, but it may serve as a paratenic (= transport) host. Ingestion of infected snake meat was described as a leading cause of human sparganosis by Kobayashi (1925).

Table 1. Global distributional records for spargana in reptiles. References: [1]Auffenberg, 1980; [2]Cho et al., 1973; [3]Cobbold, 1861; [4]Guyénot and Naville, 1924; [5]Hasegawa, 1985; [6]Honda, 1938; [7]Iwata, 1933; [8]Joyeux and Baer, 1927; [9]Kagei, 1973; [10]Kagei and Kifune, 1977; [11]Kobayashi, 1925; [12]Lai et al., 2004; [13]Liu et al., 2004; [14]Odening et al., 1980; [15]Parona, 1887; [16]Pinnell and Schmidt, 1977; [17]Polonio, 1860; [18]Seo et al., 1964; [19]Shimalov and Shimalov, 2000; [20]Weinstein et al., 1954; [21]Yildirimhan et al., 2007; [22]this paper; [23]Auffenberg, 1981; [24]Sanda et al. 2001; [25]Yanagisawa et al., 1999; [26]Miura et al., 2001; [27]Fukumoto et al., 2006; [28]Hughes et al., 1941.

Species	Plerocercoid designation	Locality	Reference	Comment
Australian realm				
Chlamydosaurus kingii	Sparganum sp.	Australia		
Dendrelaphis punctulatus	Sparganum sp.	Australia	28	as Dendrophis punctulatus
Morelia spilota	Sparganum sp.	Australia	28	as Morelia argus
Pseudechis porphyriacus	Sparganum sp.	Australia	28	
Pseudonaja textilis	Sparganum sp.	Australia	28	as Demansia textilis
Varanus gouldii	Sparganum sp.	Australia	28	
Varanus varius	Sparganum sp.	Australia	28	
Ethiopian realm				
Echis sp.	Plerocercus echicola	East Africa	28	
Neotropical realm				
Corallus hortulanus	Sparganum sp.	American tropics	28	as Boa enydris
Lachesis muta	Plerocercus lachesis	American tropics	28	as Lachesis mutus
Oriental realm				
Bungarus multicinctus	Spirometra erinaceieuropaei	Taiwan	12	
Cryptelytrops insularis	Spargana	Timor-Leste	22	
	Spargana	Komodo Island	23	as Trimeresurus albolabris
Dendrelaphis inornatus timorensis	Spargana	Timor-Leste	22	
Dendrelaphis pictus	Spargana	Komodo Island	23	
Ptyas mucosa	Ligula colubri blumenbachii	India	3	as Coluber blumen-bachii
Python molurus	Dibothrium milliapharyngeus	India	28	
Varanus komodoensis	Spargana	Komodo Island	1	
	Spirometra sp.	Flores Island	16	
Varanus salvator	Spargana	Komodo Island	1	
Palaearctic realm				
Amphiesma pryeri	Sparganum mansoni	Okinawa	5	as Natrix pryeri pryeri
Dinodon rufozonatum	Sparganum mansoni	Korea	20	
	Sparganum mansoni	Korea	18	
	Sparganum mansoni	Korea	2	
Elaphe climacophora	Diphyllobothrium erinacei	Japan	7	
	Diphyllobothrium erinacei	Japan	9	
Elaphe dione	Diphyllobothrium mansoni	Korea	6	
	Sparganum mansoni	Korea	2	
Elaphe quadrivirgata	Spirometra erinaceieuropaei	China	13	
	Spirometra erinaceieuropaei	Japan	24, 25, 27	
	Diphyllobothrium erinacei	Japan	7	
	Diphyllobothrium erinacei	Japan	9	
	Diphyllobothrium erinacei	Japan	10	
Elaphe rufodorsata	Sparganum mansoni	Korea	2	
Elaphe schrenckii	Sparganum mansoni	Korea	11	
	Diphyllobothrium mansoni	Korea	6	
Euprepiophis conspicillata	Diphyllobothrium erinacei	Japan	7	as Elaphe conspicil-lata
Gloydius halys	Sparganum mansoni	Japan	9	as Agkistrodon halys
	Sparganum mansoni	Korea	11	as Agkistrodon halys
	Diphyllobothrium mansoni	Korea	6	as Agkistrodon halys
	Sparganum mansoni	Korea	2	as Agkistrodon halys

Hierophis spinalis	Sparganum mansoni	Korea	2	as Zamensis spinalis
Natrix maura	Ligula pancerii	Italy	15	as Tropidonotus viperinus
Natrix natrix	Spirometra	Germany	14	
	Spirometra erinacei	Belarus	19	
	Diphyllobothrium erinaceieuropaei	Turkey	21	
	Ligula pancerii	Italy	17	as Tropidonotus natrix
	Plerocercoides pancerii	Italy	4	as Tropidonotus natrix
	Sparganum	Italy	8	as Tropidonotus natrix
Nerodia sipedon	Sparganum browni	New York, USA	28	as Natrix sipedon
Ovophis okinavensis	Sparganum mansoni	Okinawa	5	as Trimeresurus okinavensis
Protobothrops flavoviridis	Diphyllobothrium erinacei	Japan	9	
Protobothrops mucrosquamatus	Spirometra erinaceieuropaei	Taiwan	12	as Trimeresurus mucrosquamatus
Rhabdophis tigrinus	Diphyllobothrium erinacei	Japan	7	as Natrix tigrina lateralis
	Diphyllobothrium erinacei	Japan	9	
	Sparganum mansoni	Korea	11	as Natrix tigrinia
	Sparganum mansoni	Korea	2	as Natrix tigrina lateralis
	Spirometra erinaceieuropaei	Japan	26, 27	
Trimeresurus elegans	Sparganum mansoni	Okinawa	5	as Trimeresurus gramineus
Vipera berus	Spirometra erinacei	Belarus	19	

Dendrelaphis inornatus timorensis represent a new host record.

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Notes on Feeding Behaviour of *Sibynophis sagittarius* (Cantor, 1839) (Serpentes: Colubridae)

(with two text figures)

Snakes of the genus *Sibynophis* are specialized hinged-toothed scincivores (Savitzky, 1981, 1983). Members are also characterized in having specialized mandibular bones in which the anterior portion of the dentary is attached to the articulation at a point of about one-third the distance from the anterior end at an acute angle to its longitudinal axis (Leviton, 1963). Schmidt (1950) mentioned that modifications of the lower jaw in *Sibynophis* indicate changes primarily concerned with food habits. In *Sibynophis*, the teeth are compressed, almost of equal size, the anterior-medial edge being knife-like, the tip somewhat rounded and the whole tooth slightly curved (Savitzky, 1983). Schleich and Kästle (2002), Sharma (2003) and Whitaker and Captain (2004) reported that *Sibynophis* feed on geckos, skinks and smaller snakes. However, the unique and free mandibular bone and fixed upper jaw bones in the snakes of the genus *Sibynophis* suggests feeding specialization to grasp smooth and slippery animals with cycloid scales. The fixed upper jaw bones act in a vice-like manner and by the independent forward and backward movement of mandible the prey is pulled inwards.

The genus *Sibynophis* is represented by nine species, distributed across southern and southeastern Asia (Leviton, 1963; Captain et al., 2004). The taxonomic problem related to *S. sagittarius* and *S. subpunctatus* was clarified by Captain et al. (2004) and the authors referred the former being distributed in central and northeastern India, the latter in western peninsular India and Sri Lanka.

Sibynophis sagittarius has been recorded from Mayurbjanj, Keonjhar, Dhenkanal, Angul, Khurdha, Sambalpur, Ganjam, Kalahandi, Boudh-Kandhamal and Koraput districts of Orissa (Mohapatra, 2008). The species is distributed in dry deciduous, moist deciduous and peninsular Sal forests in Orissa and is found below rock boulders, logs and leaf litters. This

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snake is diurnal in habit and mostly encoun-
tered solitary while crossing forest roads or in
leaf litters in the morning and evening hours.
On 1 January 2010 at 1030 h an individual of
Sibynophis sagittarius (Cantor, 1839) was ob-
served at Kamakshya Nagar (20° 57' 4.9" N,
85° 36' 1.6" E) of Dhenkanal District, Orissa,
India. The snake was located on the floor of a
Sal forest actively moving among the dry leaf
litter. The substrate was covered with small to
large boulders, sparse leaf litters and dry veg-
etation. While attempting to take a photograph
of the snake, it was found chasing a Rampho-
typhlops braminus. After a short distance the S.
sagittarius was observed trying to find the head
of the blind snake by moving aside and look-
ing at the forward movement. The head of the
blind snake was caught just behind the neck and
when it tried to escape, by roll-
ing and coiling its body around
the S. sagittarius, it was caught
strongly by slightly bending
the head (not by constrict-
ing). The prey was swallowed
alive, which was noticed by
the movement of the snake till
the tail tip was swallowed. The
whole process from catching
the neck of the prey till swal-
lowing the tail tip took almost
four min.

From the same habitat, an-
other *Sibynophis sagittarius*
of body length 157 mm, was
collected on the same date and
kept in captivity to study feed-
ing preferences. The snake
was kept in a terrarium of 0.7
x 1 m, having a soil substra-
tum of 6 cm, with a few rock
boulders and some dried Sal
leaves, for about a week. The
snake was observed to be ac-
tive by day, moving in the ter-
rarium and frequently entering
heaps of stones and leaf litters.
Small lizards of the species
*Eutropis macularia, E. cari-
nata, Hemidactylus brookii*
and *H. frenatus,* along with
Ramphotyphlops braminus (2

individuals each) were released into the terrar-
ium on the eighth day. Among all the species,
it was observed that, the snake approached one
of the blind snakes by following its movement
and tried to find the head by proceeding for-
ward. After the blind snake was caught behind
the neck, it was swallowed head first. The body
of the prey was subsequently ingested by the
repeated forward movement of the lower jaw,
arching to the body of the prey and then pulling
backward. The process of feeding on *R. brami-
nus* by *S. sagittarius* is depicted ie Figs. 1–2.
The feeding behaviour was similar to the ear-
lier observation and ingestion was of cat five
min duration.

I thank S. K. Dutta (North Orissa University),
Abhijit Das (Aaranyak) and Cuckoo Mahapatra
(Utkal University) for discussion and encour-

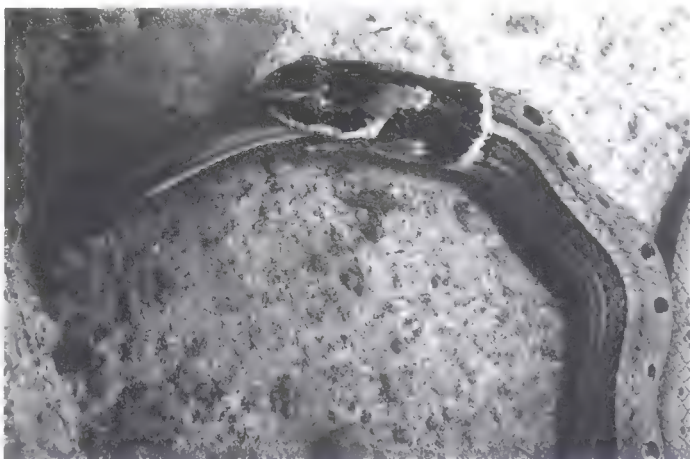Figure 1. *Sibynophis sagittarius* following the head of the Blind snake *Ramphotyphlops braminus.*

Figure 2. *Sibynophis sagittarius* swallowing the *Ramphotyphlops braminus.*

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Population densities of the forest lizard, *Calotes rouxii* from Karnataka State, south India

(with one text-figure)

India has a fauna of over 199 species/subspecies of lizards that are distributed in diverse ecological conditions (Venugopal, 2010). However, little is known of their population status. Population estimates based on rigorous sampling are needed to understand the status of any taxa. Data on population density of agamid species, *Sitana ponticeriana* at Gabbur, Dharwad district, and *Psammophilus dorsalis* at Hampi village, both from Karnataka, and *Salea anamallayana* from Eravilulum National Park, Kerala, are available in Shanbhag et al. (2003), Radder et al. (2005) and Deepak and Vasudevan (2008), respectively. *S. ponticeriana* is a ground dwelling, fossorial species, while *P. dorsalis* inhabits the rocky habitat with little vegetation and *S. anamallayana* is an arboreal lizard found in grasslands, shola and tea plantations. In this paper, we present data on the population density of *Calotes rouxii* from Gobral village (15°19'N, 74°36'E; altitude 430 m asl), Uttar Kannada, Karnataka, south-western India.

The study site selected for the survey is a forest area and is bordered by the road on one side. It is a semi-deciduous forest dominated by bamboos, *Anacardium semicarpus*, *Bauhinia* sp. and *Terminalia alata* (Teak). Sympatric lizard species include *Calotes versicolor*, *Draco dussumieri*, *Eutropis* sp. and *Hemidactylus leschenaultii*. In the present study, we examined nine belt transects each with 25 × 50 m for lizards. The surveys were conducted on four consecutive days (20–23 May 2009) to estimate density of *C. rouxii*. The boundaries of transects were marked with colored cloth flags numbered serially along the roadside and also on the opposite ends. Six to seven observers participated in the survey. Though at a given time six or seven transects were surveyed, each transect was surveyed thrice during four days survey period; once between 09:30–10:30 h, 10:40–11:40 h and 11:50–12:50 h. Each transect was scanned by different individuals on different days. Each

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observer walked randomly through a given transect from one end to the other, between the trees and searched for lizards (on tree trunks, bushes and on ground) and noted the number of *C. rouxii* encountered. Each observer took ~1 h to survey a given transect. On spotting *C. rouxii,* its sex, perch height (lizards up to ~8 m could be spotted with the naked eye) and perch diameter were recorded visually. Eight males and seven females were caught to record their snout-vent length (SVL) and body mass and released subsequently. Air temperature was recorded every 30 min during the survey period.

Data from all transects were pooled for statistical analysis. The horizontal distribution of lizards was computed by using Lloyd's mean crowding index, $r = m_{c/m}$, $m_c = m + (\sigma^{2/m} - 1)$ with m_c = mean crowding index, m = mean number of individuals per sample area of size i, σ^2 = variance of number of individuals per sample area of size i. An index r higher than 1 indicates non-random distribution (Lloyd, 1967). The variation in the total number of males and females recorded was analyzed by Mann-Whitney U-test. Data are represented as mean ± SE.

The total number of *C. rouxii* recorded during the four consecutive days in nine transects was 45, 85, 70 and 46, respectively. Thus the mean number of recorded lizards was 61.5 ± 9.73 in an area of 1.125 ha. The number of lizards encountered on the first and fourth day of our survey was low and may be attributed to cloudy weather on these days. The highest number of lizards was spotted between 10:40 and 11:40 h and lowest during noon, i.e. from 11:50 to 12:50 h. Crowding index analysis revealed that the overall horizontal distribution of *C. rouxii* within the study area was clustered (mean crowding index: $r = 1.109$, $i =$ 1 ha). *C. rouxii* males showed random distribution ($r = 0.96$, $i = 1$ ha), whereas females showed clustered distribution ($r = 1.08$, $i = 1$ ha) within the study area. The ambient temperature ranged from 25–33°C (mean 29.21°C ± 1.21;

Fig. 1). The total number of males (39.5 ± 5.48) recorded was significantly more than the females (22 ± 4.69) ($U = 0$, $P = 0.050$; Fig. 1). The males were larger in SVL (67.42 ± 0.69 mm) than females (61.59 ± 1.59 mm) and they were found to be perching higher at broader perches unlike the females.

Ishwar et al. (2003) reported on the population structure of eight species of agamid lizards, including *C. rouxii* in the peripheral fragments at Kalakad-Mundanthurai Tiger Reserve and Annamalai Hills, and have reported 16 individuals in a total area of 201 ha. Also, Kannan and Bhupathy (2009) have surveyed nine species of agamid lizards, including *C. rouxii* with respect to the altitudinal range of the study area, in Nilgiri Biosphere Reserve and Indira Gandhi Wildlife Sanctuary, Tamil Nadu. Their study reported low percentage of *C. rouxii* at lower altitude (600 m) while higher percentage was recorded at altitude between 600–1,200 m. They mentioned altitudinal range instead of the total area surveyed. Our study recorded 54.91/ha lizards at an altitude of 430 m in the Gobral forest area. It is suggested that the distribution and abundance of *C. rouxii* is not only regulated by varying altitudinal range but may also depend on the type of vegetation, habitat, and/or climatic conditions. Further, the variations in the density of *C. rouxii* reported in all the studies including this study, may be because of the different methods used for counting of lizards. The random distribution
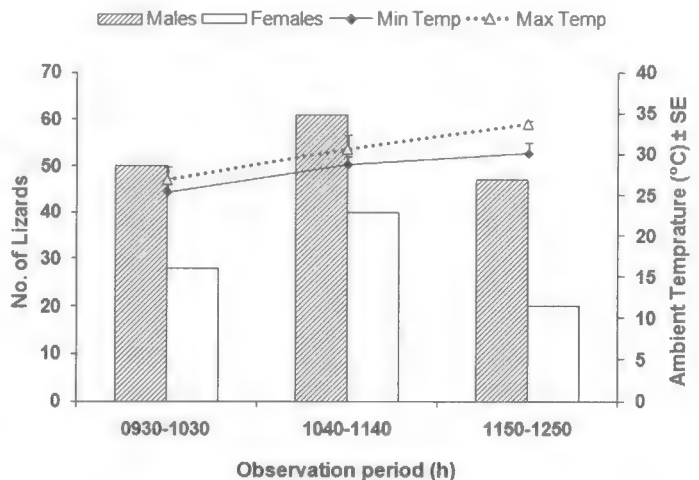

Figure 1. Number of male and female *Calotes rouxii* recorded on four consecutive days, plotted against time of survey and ambient temperature.

of males in the present study may be because the study area is dominated by tall trees, and males prefer to perch at higher heights. However, the females seem to be more selective in choosing areas dominated by bamboos and hence, showed clustered distribution.

The present study provides baseline data on population density of forest *Calotes* in a forest area near Gobral village in Karnataka. More such surveys need to be undertaken at different times of the year, especially outside breeding season, to understand population dynamics of the species.

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First record of *Xenochrophis melanzostus* (Gravenhorst, 1807) on Bali Island, Indonesia

(with one text-figure)

The *Xenochrophis piscator* (Schneider, 1799) complex is widely distributed across Pakistan, India and south-east Asia, including Java, and was recently reviewed by Vogel and David (2007). These authors showed that *Xenochro-phis melanzostus* (Gravenhorst, 1807) is a valid species, distinct from *X. piscator* and *Xenochro-phis flavipunctatus* (Hallowell, 1861), differing by its dorsal pattern, nuchal marking, subocular streak, ventral and subcaudal scale counts (see Table 1). Previously, *X. melanzostus* was regard-ed as a widely distributed species. There are old records from the Andaman Islands (Das, 1999; Whitaker and Captain, 2004), Sulawesi (In den Bosch, 1985), Borneo and Sumatra (de Rooij, 1917; Manthey and Grossmann, 1997; David and Vogel, 2006). The population on the Anda-man Islands was shown to be non-conspecific, for which the name *Xenochrophis tytleri* (Blyth, 1863) is available (Vogel and David, 2007). The records on Borneo and Sulawesi were shown to be erroneous (Stuebing and Inger, 1999; de Lang and Vogel, 2005). The occurrence on Sumatra is doubtful (Vogel and David, 2007). Hence, cur-rent evidence points to *X. melanzostus* being an endemic of Java. There was no record of *Xeno-chrophis melanzostus* or other members of the

of males in the present study may be because the study area is dominated by tall trees, and males prefer to perch at higher heights. However, the females seem to be more selective in choosing areas dominated by bamboos and hence, showed clustered distribution.

The present study provides baseline data on population density of forest *Calotes* in a forest area near Gobral village in Karnataka. More such surveys need to be undertaken at different times of the year, especially outside breeding season, to understand population dynamics of the species.

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First record of *Xenochrophis melanzostus* (Gravenhorst, 1807) on Bali Island, Indonesia

(with one text-figure)

The *Xenochrophis piscator* (Schneider, 1799) complex is widely distributed across Pakistan, India and south-east Asia, including Java, and was recently reviewed by Vogel and David (2007). These authors showed that *Xenochrophis melanzostus* (Gravenhorst, 1807) is a valid species, distinct from *X. piscator* and *Xenochrophis flavipunctatus* (Hallowell, 1861), differing by its dorsal pattern, nuchal marking, subocular streak, ventral and subcaudal scale counts (see Table 1). Previously, *X. melanzostus* was regarded as a widely distributed species. There are old records from the Andaman Islands (Das, 1999; Whitaker and Captain, 2004), Sulawesi (In den Bosch, 1985), Borneo and Sumatra (de Rooij, 1917; Manthey and Grossmann, 1997; David and Vogel, 2006). The population on the Andaman Islands was shown to be non-conspecific, for which the name *Xenochrophis tytleri* (Blyth, 1863) is available (Vogel and David, 2007). The records on Borneo and Sulawesi were shown to be erroneous (Stuebing and Inger, 1999; de Lang and Vogel, 2005). The occurrence on Sumatra is doubtful (Vogel and David, 2007). Hence, current evidence points to *X. melanzostus* being an endemic of Java. There was no record of *Xenochrophis melanzostus* or other members of the

Table 1. Main morphological characters of the Bali specimen of *Xenochrophis melanzostus* compared with related species (comparative data from Vogel and David, 2007).

Data (females)	Bali specimen	*X. melanzostus*	*X. flavipunctatus*	*X. piscator*	*X. tytleri*
ventrals	136	136–142	131–143	136–151	144–145
subcaudals	79	66–77	70–87	68–87	77–79
total length	787	975	974	1020	920
tail length/total length	0.235	0.233–0.254	0.256–0.306	0.264–0.290	0.279
nuchal mark	wide V	wide V	V like	inverted V	Wide V

Xenochrophis piscator complex from Bali (de Rooij, 1917; Manthey and Grossmann, 1997; Iskandar and Colijn, 2001; McKay, 2006).

A single specimen of the genus *Xenochrophis* was collected on 12 August 2009, in the mangrove area of Perancak Beach, Jembrana, Bali (08.39121°S, 114.62742°E; 21 m asl), ca. 100 m north of the Balai Riset dan Observasi Kelautan (BROK, or Marine Research and Observation Office), or 1.3 km north of the Perancak Beach coastal line. The specimen was collected alive, preserved and deposited in the Animal Taxonomy Laboratory of Faculty of Biology, Gadjah Mada University (collection number: SHBIUGM/BALI 730001) (Fig. 1).

The specimen shows the following characters: total length 78.7 cm, SVL 60.2 cm, weight 102.9 g, female. Characteristic for species of this complex are the two black streaks running from the eye to the supralabial scales, the first streak running from the lowest postocular scale to sixth supralabial, while the second streak running from temporal scale to 8th supralabial. It has

9 supralabial scales and 9 infralabial scales, 3 postocular scales, 1 preocular ocular scale and a loreal scale. Head shield formula is 2 small triangular internasal scales, 2 prefrontal scales, a frontal scale shaped as an elongated hexagon, 2 supraocular scales, 2 large parietal scales with a nuchal scale lying at posterior edge of parietal scale. The nuchal mark looks like a wide V. There are 136 ventral plates and 79 pairs of subcaudal plates, both of these scales with clearly black margins. Anal plate is divided, with no black margin. The specimen has two scars in the ventral part. The specimen shows the typical blotches pattern, which is one of the two patterns known for *Xenochrophis melanzostus* (longitudinal stripes or blotched pattern [Hodges, 1993; Vogel and David, 2007]). This blotched pattern is clearly seen in first half body, while it is more confused in the second half of the body. Dorsal scales are keeled, with 19 rows around midbody.

The pholidosis of this specimen is typical for the species *X. melanzostus* (Table 1) except for the number of subcaudal scales which is higher by two scales than the value given by Vogel and David (2007). Bergman (1958) gave the number of subcaudal scales for females as 65–80. From Table 1, it is evident that this specimen differs from *X. piscator* and *X. flavipunctatus* by its much shorter tail.

The mangrove area where *Xenochrophis melanzostus* was collected is an area with brackish water for which the water availability depends on the rise and fall of the tide. The salt water floods the mangrove when high tide occurs,

Figure 1. *Xenochrophis melanzostus* from Jembrana, Bali, Indonesia (SHBIUGM/BALI 730001).

but empties after ebb tide, forming puddles in several parts of the mangrove. In these puddles are a number of fish which presumably are prey of *Xenochrophis melanzostus*. In the north and south of this mangrove lies a perennial river with brackish water. In Java, *Xenochrophis melanzostus* is usually found in freshwater areas that are often disturbed by humans, for example rice fields, fish ponds and rivers.

This first record of *Xenochrophis melanzostus* for Bali proves that the species is not endemic to Java. McKay (2006) listed 31 snake species for Bali, so this number should be raised to 32. At the moment, it cannot be ruled out, that this species was introduced to Bali recently.

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New specimens of *Eublepharis angramainyu* Anderson & Leviton, 1966 (Sauria: Eublepharidae), from south-western regions of the Iranian Plateau

(with four text–figures)

The genus *Eublepharis* encompasses five valid species: *Eublepharis angramainyu* Anderson and Leviton, 1966; *Eublepharis macularius* (Blyth, 1854); *Eublepharis fuscus* (Börner, 1981); *Eublepharis turcmenicus* Darvesky, 1977 and *Eublepharis hardwicki* (Günther, 1874). The range of this genus extends from Turkey to India including Iran, Iraq, Turkmenistan, Afghanistan, Pakistan and India (Grismer, 1988; Das, 1997; Anderson, 1999; Göçmen et al., 2002; Tosunoğlu et al., 2005; Üzüm et al., 2008). A unique characteristic of the genus *Eublepharis* is a fat tail used for the storage of fat, which can be used as a valuable energy resource (Terrell et al., 2003). The tail is typically shorter than the length of the head and body, with a dilated middle and pointed tip (Szczerbak and Golubev, 1996). Digits are short, cylindrical, clawed, and have transverse lamellae underneath (Göçmen, 2003).

The leopard gecko, *Eublepharis angramainyu* was originally described a specimen collected from an old road between Masjed–Suleiman and Batwand, Khuzestan Province, Iran, in 1966 by Anderson and Leviton. *Eublepharis angramainyu* occurs in the western foothills of the Zagros Mountains and in the upper Tigris-Euphrates basin in Iran, Iraq, and north-east of Syria (Anderson and Leviton, 1966; Anderson, 1999). Recently a new specimen of this species was recorded from south-eastern Anatolia and Kara Dagh–Arsanlì of Şanliurfa Province, Turkey (Göçmen et al., 2002; Tosunoğlu et al., 2005; Üzüm et al., 2008). Grismer (1989) placed *Eublepharis ensafi* Baloutch and Thireau in the synonymy of *E. angramainyu* (Anderson, 1999).

During field work on the herpetofauna of western and south-western Iranian Plateau, from June 2008 to September 2009, 15 specimens of *Eublepharis angramainyu* (including six males and nine females) were collected from three different localities as follows: Sumar (33°52'N, 45°33'E) and Naft–Shahr (33°59'N, 45°30'E) in Kermanshah Province, Mehran (33°7'N, 46°10'E) and Dehloran (32°41'N, 47°16'E) in Ilam Province and Pol-e-Dokhtar (33°09'N, 47°42'E) in Lorestan Province (Figs. 1–2). The specimens were collected in the field by hand. Furthermore, for comparison, two specimens of *E. angramainyu* (Masjed–Suleiman Khuzestan Province locality) from the Museum of Razi Vaccine and Serum Research Institute, were studied.
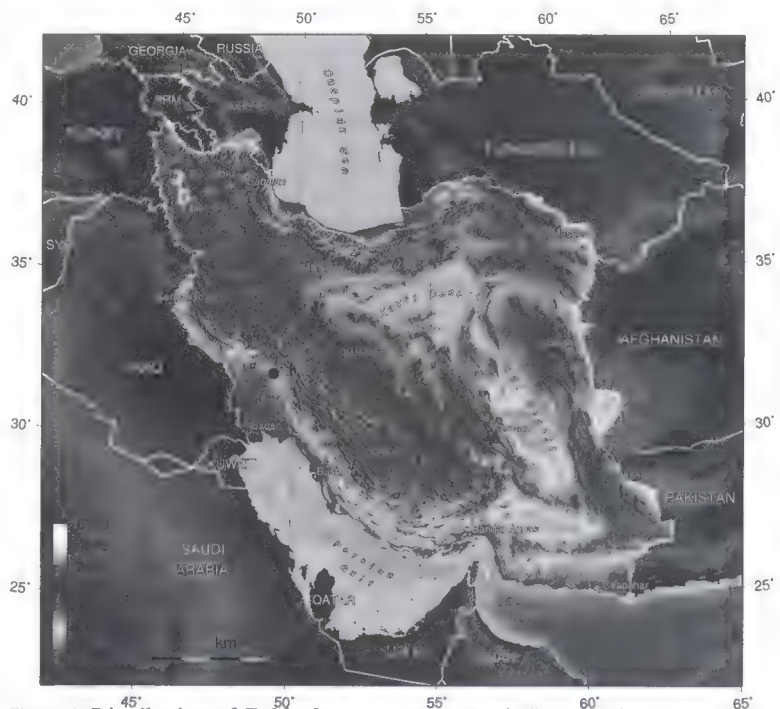

Figure 1. Distribution of *Eublepharis angramainyu* in Iran. Dark spots = previous records (Anderson and Leviton, 1966); pale spots = new records (treated here).

Table 1. Primary metric and meristic characters in adult *Eublepharis angramainyu* specimens used in this study.

Characters	Definition
SVL	Snout-vent length (from tip of snout to anterior edge of cloacae), mm
TL	Tail length (from posterior edge of cloacae to tip of tail), mm
HL	Head length (from tip of snout to anterior edge of tympanum), mm
WH	Head width (greatest distance between ear openings), mm
HH	Head height of, mm
EYD	Eye diameter (from upper corner to lower corner of eye), mm
NED	Nostril-eye distance(from anterior corner of eye to posterior edge of nostril), mm
EED	Eye-ear distance (from the posterior corner of eye to anterior edge of tympanum), mm
IOR	Interorbital distance(between anterior corner of orbits), mm
NL	Neck length (from the posterior edge of tympanum to anterior edge of shoulder), mm
SW	Snout width (between nostrils), mm
MW	Mental width, mm
LFo	Length of forelimb, mm
LHi	Length of hindlimb. mm
EVL	Ear opening vertical length, mm
EHL	Ear opening horizontal length, mm
DHF	Distance between hindlimbs and forelimbs, mm
SL	Number of supralabials
IL	Number of infralabials
EFS	Eyelid fringe of scales
BSNS	Number between suprnasal scales
NDT	Number of dorsal tubercles body
SDLT	Subdigital lamellae under the fourth toe
SDLF	Subdigital lamellae under the fourth finger
NVS	Number of ventral scales (of anterior edge of shoulder to anterior edge of cloacae)
RVS	Row of ventral scales (in across rows)
PP	Preanal pores

All the metric and meristic characters were recorded on live specimens. Eight of the specimens were anaesthetized with ether, fixed with 96% ethanol, and later kept in 70% ethanol. They were deposited in the Razi University

**Figure 2.** *Eublepharis angramainyu* in its natural habitat.

Zoological Museum (RUZM). In addition, one pair of the studied specimens is kept in the terrarium of Razi University Zoological Lab, and five specimens were released back to the natural habitat. Morphometric measurements were taken with digital calipers to the nearest 0.01 mm. The terms used in the study conforms with Grismer (1988), Szczerbak and Golubev (1996), Anderson (1999) and Uzüm (2008).

The main morphological characters of the studied specimens of *Eublepharis angramainyu* and their basic data are presented in Tables 1–2.

Description of new specimens.– The supranasal plate of the female specimens from Ilam Province (RUZM– EE10.5, RUZM–EE10.8, RUZM–EE10.13, RUZM–EE10.11, RUZM–EE10.14, RUZM–EE1015, RUZM–EE1016) is separated by one or two scales, and the male specimen (RUZM–EE10.7) has two pentagonal internasal plates. The single female specimen from Kermanshah Province (RUZM–EE10.4)

Table 2. Measurements of adult *Eublepharis angramainyu* specimens used in this study. References: M = Male, F = Female. * = Specimen recorded by Anderson and Leviton (1966).

Characters	Ilam F (n=7) Range	Ilam F (n=7) Mean	Ilam M (n=2) Range	Ilam M (n=2) Mean	Kermanshah F (n=1) Range	Kermanshah F (n=1)	Kermanshah M (n=2) Range	Kermanshah M (n=2) Mean	Lorestan F (n=1)	Lorestan M (n=2) Range	Lorestan M (n=2) Mean	Khuzistan* M (n=2) Range	Khuzistan* M (n=2) Mean
SVL	130.74-147.07	138.34	142.48-149.70	146.09	-	155	140.33-149.70	145.01	142.5	141.98-152.44	147.21	152.65-167.29	159.97
TL	49.44-100	69.32	47.78-60.49	54.13	-	-	95.39-96.88	96.13	60.27	96.26-100.89	98.6	82.12-84.20	83.16
LH	33.30-39.91	35.65	33.30-40.09	36.69	-	35.54	31.84-38.84	35.34	34.99	33.73-35.70	34.72	35.53-39.05	37.29
WH	25.22-33.10	28.04	27.99-28.35	28.17	-	29.68	28.20-31.88	30.04	26.67	25.02-28.70	26.86	26.89-29.90	28.39
HH	7.13-10.21	8.51	7.71-8.75	8.23	-	8.76	8.35-9.19	8.77	8.34	8.60-9.80	9.20	8.51-9.88	9.19
EYD	4.48-7.13	5.72	4.93-6.27	5.6	-	5.17	5.11-7.43	6.27	4.95	.96-5.48	45.22	6.76-6.87	6.77
NED	9.00-9.80	9.36	9.23-9.61	9.42	-	10.42	9.30-9.99	9.64	6.77	9.05-9.10	9.07	10.18-10.79	10.48
EED	12.91-15.30	13.59	14.34-14.96	14.65	-	15.35	14.58-15.74	15.16	13.46	13.30-14.70	14.00	15.15-15.71	15.43
IOR	9.88-10.42	10.01	8.24-9.96	9.1	-	10.16	10.56-10.64	10.60	9.93	8.90-9.37	9.13	11.58-11.87	11.72
NL	18.05-28.11	22.51	20.28-26.04	23.16	-	28.00	26.80-30.00	28.40	29.98	20.50-24.23	22.36	27.16-30.02	28.59
SW	4.48-6.00	5.25	5.54-5.59	5.56	-	5.38	4.51-6.01	5.26	5.12	4.82-5.03	4.92	5.60-5.73	5.66
MW	4.18-6.00	4.81	3.32-5.88	4.6	-	3.30	4.76-5.75	5.25	3.59	4.40-4.78	4.59	5.03-5.23	5.13
LFo	48.55-55.00	50.51	56.35-57.42	56.88	-	55.94	48.59-66.34	57.46	43.90	56.16-57.00	56.58	53.05-54.99	54.02
LHi	58.42-67.00	62.37	66.84-67.50	67.17	-	72.40	52.78-67.16	59.97	68.56	67.90-69.10	68.50	61.08-74.20	67.64
EVL	4.84-6.00	5.55	5.46-7.33	6.39	-	5.37	5.19-7.59	6.39	6.64	4.53-5.42	4.97	5.17-5.78	5.47
EHL	2.37-4.90	2.91	3.26-4.55	3.90	-	2.49	2.31-2.91	2.61	3.04	2.43-2.60	2.51	4.47-5.56	5.01
DHF	68.83-73.96	72.47	72.58-76.52	74.55	-	86.14	75.27-83.97	76.62	76.98	68.37-72.42	70.39	89.96-98.22	94.09
SL	10-13	-	10-10	-	-	11	10-11	-	11	11	-	10-11	-
IL	10-12	-	10-10	-	11/10 left/right	11	11-12	-	11	12/11	-	10-11	-
EFS	40-42	-	40	-	-	41	40	-	40	40-42	-	40	-
BSNS	1-2	-	2-2	-	-	2	0-1	-	1	1-2	-	1-2-3	-
NDT	17-21	-	19-23	-	-	19	19-20	-	23	18-23	-	15-20	-
SDLT	23-25	-	23-23	-	-	24	22	-	25	25	-	25	-
SDLF	16-21	-	17-17	-	-	18	18	-	17	18	-	17-20	-
NVS	90-102	-	98	-	-	97	85-92	-	95	92-99	-	95-97	-
RVS	30-31	-	23	-	-	25	28-30	-	23	21-23	-	26-27	-
PP	10-13	-	10-10	-	-	13	10	-	9	12	-	11-12	-
SVL/LT	2.31-1.47	-	2.98-2.47	-	-	-	1.37-1.55	-	2.36	1.47-1.51	-	1.86-0.19	-
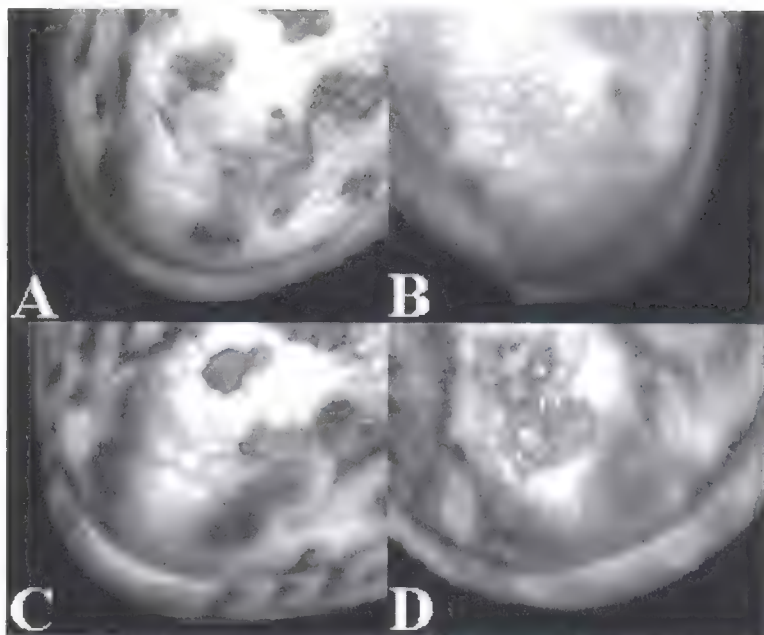
Figure 3. Scales between supranasal plates: (A) supranasals in contact (RUZM-EE10.2); (B) a pentagonal scale between supranasals (RUZM-EE10.8); (C) a semicircular scale between supranasals (RUZM-EE10.7); (D) two scales between supranasals (RUZM-EE10.9).
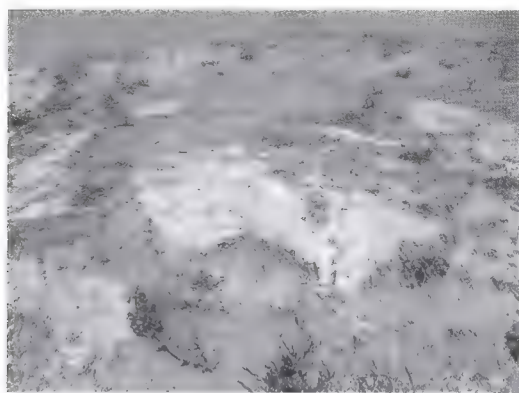
Figure 4. Habitat of *Eublepharis angramainyu*, 2 km west of Haftcheshme Village, south-east of Pol-e-Dokhtar, Lorestan Province, south-western Iran (> 660 m asl).

having two plates between the supranasals, but the two males (RUZM–EE10.2, RUZM–EE10.3), in this position, have supranasal plates in contact. The internasals of the single female specimen (RUZM–EE10.10) and two male specimens (RUZM–EE10.9, RUZM–EE10.12) from Lorestan Province are similar to the specimens from Ilam Province (Fig. 3, female). The chin shields of all the specimens (the first row of postmentals) are in contact with first lower labials. There are 10 developed V–shaped rows

of preanal pores in the male specimens from Ilam and Kermanshah Provinces, and 12 preanal pores in the single male specimen from Lorestan. On the other hand, the number of rudimentary preanal pores in females varied from 9–13.

Dorsal tubercles are conical, smaller than intertubercle spaces, and surrounded by 10–12 scales; tail tubercles are conical, directed backward. Tubercle diameter size are as follows: dorsum > leg > arm.

Ventral scales smooth; hexagonal, in 22–25 longitudinal series on mid–body; the female specimens from Ilam Province, and a male having 23 ventral scales in a transverse row; the male specimens from Kermanshah being similar to the male specimens from Ilam Province and the male specimens from Lorestan province bearing 21–23 longitudinal series of ventral scales on midbody, and the female specimen having 23 longitudinal series of ventrals on midbody. There are 19–21 dorsal tubercles in a single transverse row in female specimens from Ilam Province; the male specimen has 23 circular tubercles in the same position. There are 19–20 dorsal tubercles in the males and 19 in the female specimen (in a single longitudinal row) from Kermanshah.

The male specimens (n = 6) from Ilam, Kermanshah, and Lorestan Provinces are adults and their SVL is 140.33–152.44 mm (mean = 146.10 mm), Tosunoğlu et al. (2005) measured SVL as 151 mm in a male specimen from Turkey. The holotype of *E. angramainyu* (a male) measured 147 mm (SVL) and the paratypes (n = 13) measured as 142–154 mm (males) and 126–137 mm (females) (Anderson, 1966). The SVL measurements of adult female specimens from the above-mentioned localities are as follows: Ilam (n = 7), 130.74–147.07 mm (mean

= 138.34 mm), Kermanshah (n = 1), 155 mm, and in Lorestan specimen (n = 1), 142.50 mm. Göçmen et al. (2002) measured SVL as 148 mm for the Arsanli specimen (a female) and Üzüm et al. (2008) measured SVL as 147.78 mm for a female specimen from south-eastern Anatolia, Turkey.

The rostral sizes of the examined specimens are almost similar. The SW/MW of the females are lower than those of males (Tables 1–2). The nostril surrounded by rostral, supranasal, first supralabial, and seven semi-circular scales. The number of fringed eyelid scales in the female specimen from Kermanshah is 40–42 and the other specimens have 40 fringed eyelid scales. The ear opening is longer that its width. The number of supralabials is 12. Ventral scales in 22–25 longitudinal series on mid–body, being hexagonal, uniform and imbricate. According to Anderson (1999), the number of longitudinal series of ventral plates ranges from 27 to 38. Üzüm et al. (2008) recorded 26 scale counts in an adult female.

The original tail consists of two parts: the proximal part consisting of whorls, with keeled tubercles and the distal part being clearly swollen and bears no tubercles.

Colouration and colour pattern.– Our specimens' body background is dark lemon–yellow with a combination of numerous dark brown spots and light thin interspaces established on a horseshoe-shaped pattern on the head; the spots becoming larger on dorsum, arranged in six longitudinal rows, tail spots can merge creating transverse bands. Limbs are also covered above with spots but from ankle to the toe and from carpal to fingers being lemon-yellow. All of the ventral surfaces whitish-cream to yellowish-cream. Adults with continuous light–yellow vertebral stripe; a juvenile has three dark brown transverse bands across dorsum of body, first continues from behind the tympanum to shoulder; 4–5 dark brown bars are on the tail.

Biological and ecological remarks.– Most specimens seen in the wild were found in rocky deserts and arid grasslands (Fig. 4), with certain differences in niche specificity. They were found in small caverns in gypsum deposits, and were collected half an hour after midnight (00:30–02:30 h), when air temperature was between 27.2–34.1°C. The specimens were collected while they were hunting spiders and fighting scorpions. The specimens observed between elevations 333–1,427 m, were solitary. One of the adult female specimens laid two oval eggs in a soft leathery cover on 21 August 2009, in the Zoology Lab at the Department of Biology, Razi University Kermanshah. The eggs measured 31–33 mm length and 15.8–17.9 mm width.

Our specimens represent the first record of the *Eublepharis angramainyu* Anderson and Leviton, 1966, from western Iran. The range extension is ca. 500 km north-west from the closest previously known locality in Masjed–Suleiman and Batwand, Khuzestan Province, south-western Iran.

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LES LÉZARDS DE L'INDOCHINE

The manuscript of a remarkable book (Fig. 1) was deposited approximately over the war years (1937–1947) at the Muséum National d'Histoire Naturelle, Paris. Its author, Réne Bourret (Fig. 2), had previously gained attention for his masterful tomes on turtles (1941), amphibians (1942), marine snakes (1935) and land snakes (in two volumes, 1936a, 1936b) of Indo-China and adjacent areas of mainland south-east Asia. This particular volume on lizards, to be the last of his major herpetological publications on a complex fauna, was to be nearly relegated to obscurity, had it not been for the industry of the Curator of Reptiles of the Paris Museum (Roger Bour) and the willingness of the publishing house (Chimaira Buchhandelsgesellschaft mbH), to make the manuscript see the light of day.

Half a century may seem an awful lot of time, and indeed, much of what's written on tropical biodiversity has the tendency to appear dated in much less time. Bourret's newly published work, printed on good quality paper and strongly bound, however, will last awhile longer, simply for lack of anything comparable to the saurofaunas of mainland Asia (Taylor's, 1963, lizards of Thailand and de Rooij's, 1915, lizards of the Indo-Malayan archipelago come closest, but there are little faunal overlap between these regions), and the wealth of detail contained in the individual species accounts.

Réne Léon Bourret (1884–1957) was born in Nérac, France, and was sent on military mission to Indo-China, then part of France's overseas territory. Subsequently, he became a surveyor, and joined the Mining and Geological Survey after World War I, when he published on local geology, and also obtained his doctorate on the

subject. Despite his training and background, it was herpetology that was Bourret's main interest, and starting from 1933, he authored no less than 25 papers on the topic, including descrip-

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LES LÉZARDS DE L'INDOCHINE


Edition Chimaira
Frankfurt am Main

Reptiles et
Amphibiens
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Figure 1. Front cover of 'Les Lézards de l'Indochine' by Réne Bourret (2009).

tions of new taxa and new distributional records. Bourret returned to France in 1947, along with his herpetological specimens, photographs and notes, the former, through donation, ending up in the museums at Paris and Toulouse.
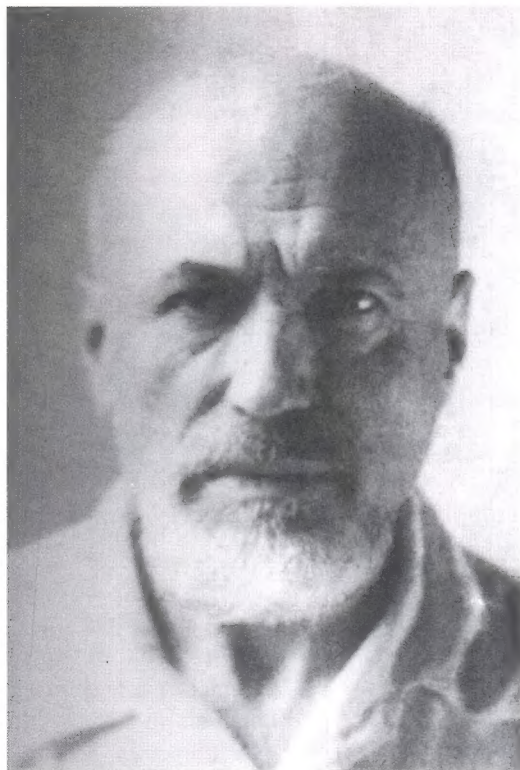
Figure 2. Portrait of Réne Bourret (1884–1957). Courtesy of Kraig Adler.

Geographical coverage of the work is worthy of a few words. Although stated to be Indo-China (largely the area that is currently Vietnam, Laos and Cambodia), similar to the other works in the series by Bourret, the area covered includes approximately the entire Indo-Chinese subrealm, stretching from Yunnan and adjacent regions of southern China, parts of north-eastern India, Myanmar, and Thailand, up to about the Isthmus of Kra (Fig. 3). Other volume in the series covered the Malay Peninsula as well.

A number of sections (preliminaries, addenda) bring this work to recent times, starting with a bilingual (English/French) foreword by Prof. Kraig Adler, an introduction (in French) to the manuscript history of 'Les Lézards de l'Indochine' by Roger Bour, the text of the main manuscript by Rene Bourret (in French), a taxonomic update of the lizards of what used to be French Indo-China by Patrick David and Ivan Ineich (in English), and an account of the life and research activities of Bourret (in French/English) by Roger Bour and Charles Blanc, in-

cluding a list of his geological and herpetological publications. The volume concludes with a selection of herpetological papers from Bulletin general de l'Instruction publique, that the editors and others considered important to reprint, given their obscurity.

A chapter-wise description of Bourret's section, that comprises the bulk of the thick tome is, of course, essential for a book review. This is the main part of the book, and its organisation is similar to Bourret's works on amphibians, turtles and snakes. It starts with a gazetteer of localities, presumably compiled by Bour and David, showing the correspondence of Bourret's localities with contemporary place names (and their geographical coordinates), Bourret's checklist of lizards of the area defined, a rather long (19 pages) account of historical aspects of studies, 24 pages of bibliography, a list of abbreviations of scientific periodicals, a chapter on lizard morphology, a tabulation of lizard distribution in south, east and south-east Asia, another table showing distribution of lizards in lowlands, compared to montane regions, a dichotomous key to lizard species of the region, and finally, the species accounts, followed by an index of scientific names. Species accounts include synonymies (ending around the late 1930s), a paragraph each for morphological description, colour description, size and geographical distribution (citing localities, in case of Indo-Chinese species). The organisation (and spelling of names) of families and genera largely follow the last great system established by Boulenger (1885a, 1885b, 1887).

I found the chapter by Patrick David and Ivan Ineich, updating the knowledge of lizards of Indo-China since the completion of Bourret's manuscript, 60–70 years ago, particularly useful, as it presents a modern checklist to the fauna, a list showing the correspondence of names by Bourret to current names, an annotated account of the fauna (including numerous species that have been described in recent years), whether any of these have material collected by Bourret at the Muséum National d'Histoire Naturelle, Paris, a list of lizard specimens deposited by Bourret at the said collection, and finally, a much needed bibliography of the lizards of Indo-China (the latter running to 25 pages).

(Planche 6 is shown here as Fig. 4), each depicting one or two species that are printed from water-colours of apparently live animals, except Plates 19 and 20, each of which show three preserved specimens of species described by Bourret (including *Paracalotes poilani*, *Tiliqua chapaense* and *Lygosoma tritaeniatum*, and *Leiolopisma ochraceum*, *Emoia laobaoense* and *Tropidophorus baviensis*, respectively). Black-and-white text figures in the text range from line art, showing animals in life, within each species account, close-ups of different parts of the body to show details of squamation, and occasional half tones, from photographs of museum-preserved specimens.

This is, then, a remarkable book, in terms of its publishing history and depth of its scientific contents, published in its original

CAMBODGE	CAMBODIA, KÂMPUCHEA		
Bokor (Boc Kor)	Khett Kampot	10°37'N 104°02'E	Kâmpôt
Kampot	Kâmpôt	10°37'N 104°11'E	Kâmpôt
Kep	Kep	10°29'N 104°17'E	Kâmpôt
Snoc Trou	Snoc Trou	12°31'N 104°27'E	Kampong Chhnang
Stung Treng	Stung [Stoeng] Treng	13°31'N 105°58'E	Stung Treng
Takeo	Takeo	10°59'N 104°46'E	Takeo

Figure 3. Geographical region covered by 'Les Lézards de l'Indochine' by Réne Bourret (page 37).

Historians of natural history will rejoice at the chapter on the life and works of Bourret, by Bour and Blanc. Long considered 'faceless' (no portrait of Bourret appeared in the compilation on the history of herpetology by Adler, 1989, and the first published portrait appears in Adler, 2009), the chance meeting of Bour with Bourret's adopted daughter, led to much valuable information on this pioneering French geologist-zoologist.

Plates are not abundant, and the species rich lizard fauna of Indo-China is relatively sparsely depicted in colour, like the other works in the series. The lizard volume has 30 colour plates

size, to be a befitting companion to Bourret's tomes on amphibians, turtles and snakes. No south-east Asian herpetologist can afford to be without a copy (although its three kilo weight would render it impossible to be carried to the field, and what is also needed is a sturdy work table). I would like to congratulate the publisher for the decision to bring out this work, and the editorial staff of the Paris Museum, for making the manuscript available for printing and for the extensive annotations for a work by a man whose works Adler (1989) described as "the most definitive reviews of Indochinese herpetology".
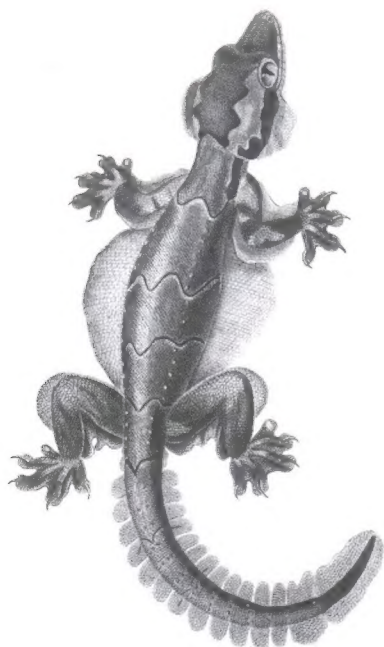
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PLANCHE 6. *Ptychozoon kuhli* STEJNEGER
(d'après DUMÉRIL & BIBRON)

Figure 4. Planche (= plate) 6 (page 198) from 'Les Lézards de l'Indochine', illustrating a *Ptychozoon kuhli*. The image is reproduced in colour in the original work.

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